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DEPARTMENT OF THE INTERIOR

UNITED STATES BUREAU OF MINES
JOHN W. FINCH, DIRECTOR

INFORMATION CIRCULAR

LONGWALL MINING METHODS IN SOME MINES OF THE MIDDLE WESTERN STATES

BY

ALBERT L. TOENGES

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DEPARTMENT OF THE INTERIOR - BUREAU OF MINES

LONGWALL MINING METHODS IN SOME MINES OF THE MIDDLE WESTERN STATES[1]

By Albert L. Toenges[2]

This circular deals primarily with the various methods of longwall mining used in some mines in certain districts of the Middle Western States. In some instances underground methods were considered comprehensively, and in others only the actual methods of mining and face advance were noted. Results obtained by the mines in output per man were compared only on the basis of an operating day, since idle time and number of men employed would not be comparable due to the great difference between mines in different districts. Man-hours per ton per operating day are noted in a general way. Material and power costs are not included.

ACKNOWLEDGMENT

The information used in preparing this paper was obtained through the courtesy and cooperation of the presidents and other officials of the companies operating the mines described. The approval of the executive of each property was obtained for publishing this manuscript, and the accuracy was checked.

NORTHERN ILLINOIS AREA

General Description of the District

The area visited is adjacent to La Salle and Peru, two towns approximately 100 miles west of Chicago. It is one of the oldest mining regions of the State.

The country is rugged and is drained by the Vermilion and Illinois Rivers. The Illinois is navigable in this vicinity.

The Rock Island, Illinois Central, and LaSalle & Bureau County Railroads serve the mines in this area.

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[1] The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from U.S. Bureau of Mines Information Circular 6893."

[2] Mining engineer, coal section, Mining Division, U.S. Bureau of Mines.

General Geology

The seam of coal mined by longwall method is the No. 2 seam geologically but is known locally as the Third vein. The thickness of the seam usually averages about 42 inches.

The No. 2 coal is long-grained, splitting most readily parallel to the bedding. Cleat is poorly developed. There are some intermittent lenses and layers of sulphur.

The roof is gray shale (soapstone) and black shale. In some places the black shale contains nodules of black "ironstone" (niggerheads of pyrite). This black shale is approximately 3 feet thick.

The bottom under the coal ranges from a hard, sandy shale, in some places approaching a sandstone, to a hard, dark-gray clay. At one mine visited the bottom was fireclay of uniform character.

Mine No. 1

Mine No. 1 is near Peru and has railroad connections. It has been in continuous operation for a great many years. The average daily production is 700 tons, and the larger part of the output is loaded into trucks and sold locally. Approximately 37 percent of the production, however, is shipped in railroad cars. The demand is seasonal, but some coal is produced the year round.

The coal seam mined is the No. 2 seam, as correlated by the Illinois Geological Survey, but locally it is called the Third vein. The average thickness here is 42 inches, and its depth at the shaft is 400 feet. Although there are some local dips, it lies comparatively level in this mine.

The roof above the coal is a gray shale (soapstone) and black shale. At places the gray shale is absent, and the black shale lies above the coal. The bottom under the coal is a hard, sandy shale.

System of Mining

The system of mining used is advancing longwall, with individual roadways. (Refer to figure 1, which is a map of a mine using this system.)

The hoisting and air shafts are protected by a solid pillar of coal. The size of this pillar varies but usually depends upon the depth of the overburden. Large pillars are desirable, not only to protect the shafts but also to provide more working places after the pillar is opened on all sides. Main entries are driven from the main shaft through the shaft pillar in four directions toward the property lines, and a connection is usually made with the air shaft. After the limits of the shaft pillar have been established, a narrow entry is driven around the pillar. From this entry openings spaced on 42-foot centers are driven at right angles. After these openings have advanced approximately 15 feet a cut is made in each direction from them and parallel to the pillar entry. Openings connect with each other and with the longwall faces. The 15-foot pillar protects the pillar entry, which serves as an air course.

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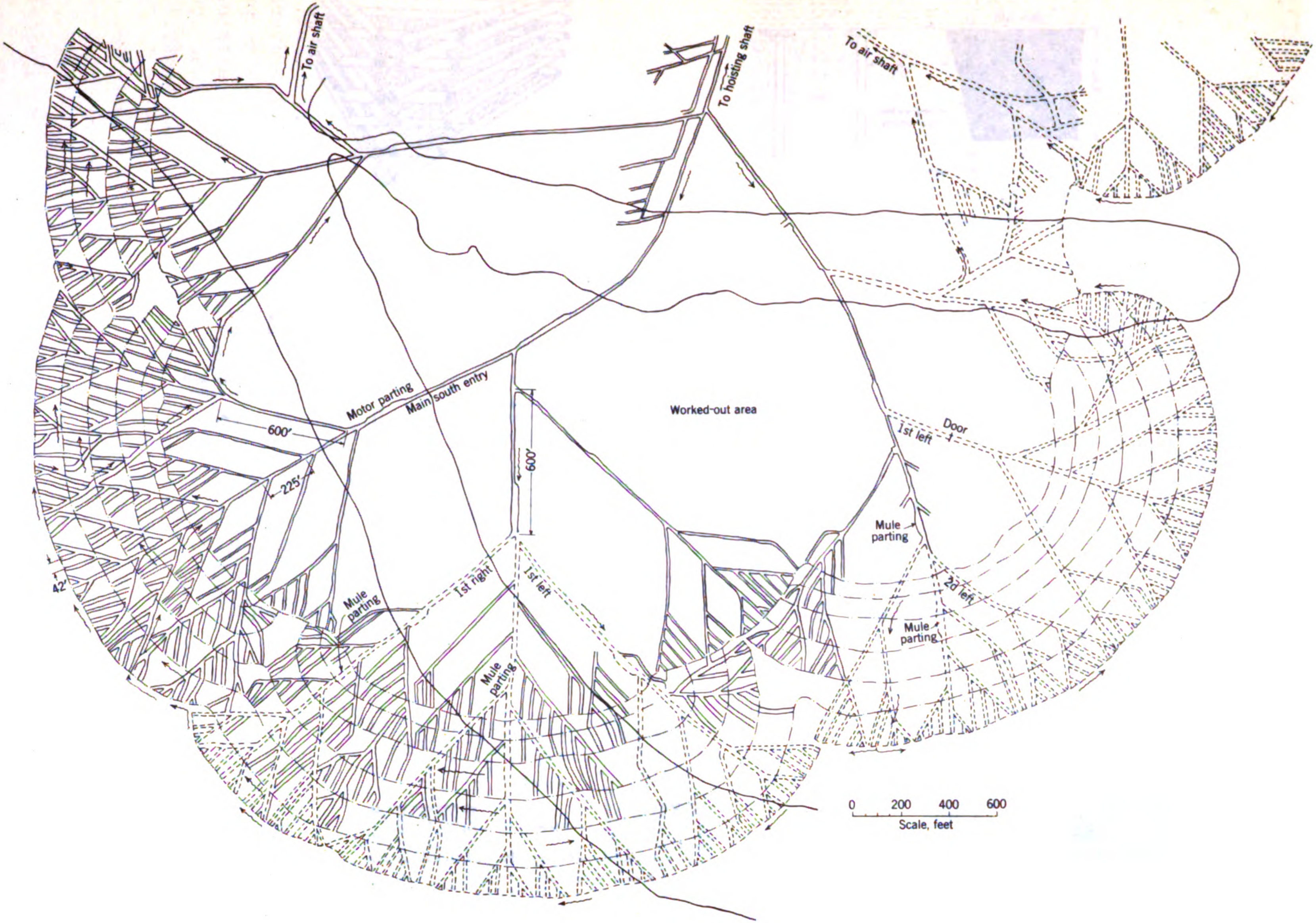
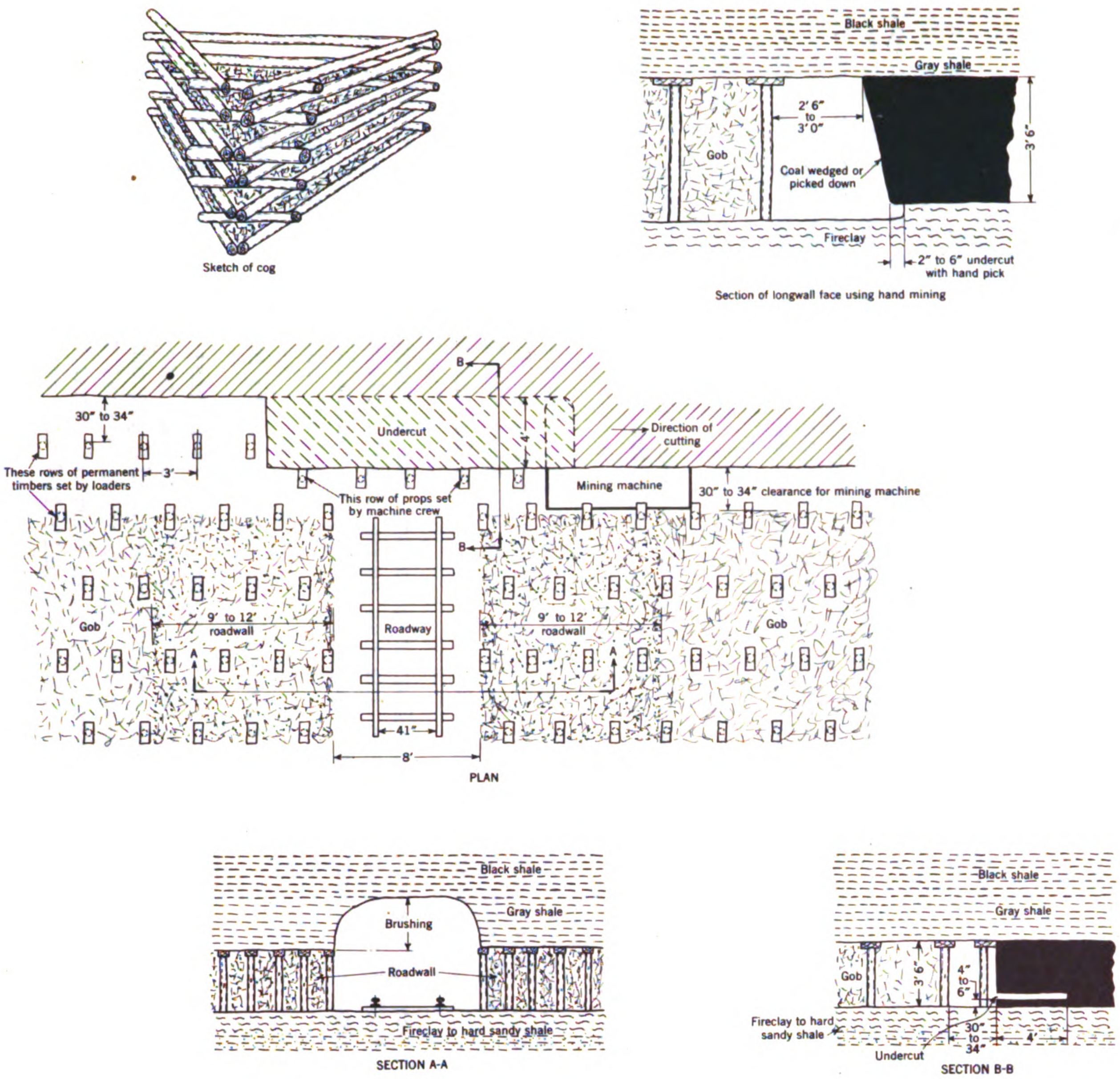


Figure 1.—Map of longwall mine in Illinois using individual roadways.



Sketch of cog

Section of longwall face using hand mining

PLAN

SECTION A-A

SECTION B-B

Figure 2.–Sketch of portion of longwall face with individual roadways–Illinois area.

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Branch entries are turned off the main entries to the right and to the left at an angle of approximately 45°. The center lines of the branch entries are usually 225 feet apart, as measured along the main entry. Individual roadways are turned off the branch entries at an angle of 45° toward the face. The center lines between roadways are usually 42 feet apart at the face. Permanent entries are turned off the main entries on 45° at approximately 600-foot centers. These permanent entries become the main haulageways, and branch entries with their roadways are turned at 45° from them.

Cutting

Longwall undercutting machines equipped with 4-foot cutter bars are used in this mine. The cut is made approximately 4 to 6 inches above the bottom of the coal, because of the hardness of the bottom beneath the coal. Three mining machines are used in this mine, all running on the day shift. They follow one another around the face, which is in the form of an arc. Each machine now in use cuts approximately 475 feet in 7 hours. Three men operate the mining machine - one runner and two helpers. One helper shovels, and the other sets props back of the machine as it progresses along the face.

Loading

There are two loaders to each roadway. Each man loads from 21 feet on each side of the roadway. A cut along the face 42 feet wide yields about 20 tons of coal.

Besides loading the coal, the loader brushes the roadways 3 feet high above the top of the coal by 8 feet wide and 4 feet toward the face. From the brushing rock they build the roadway walls and packwall along the face. The contract with the loader includes the price to be paid for brushing.

After the coal is removed the loader sets a line of props along the face and 30 to 34 inches from it. These props are set on approximately 3-foot centers. There is no additional pay for this timbering, as it is included in the tonnage price paid the loader.

Figure 2 is a sketch of a roadway in this mine.

Where a roadway is turned off the entry a triangular crib of timber, filled partly with rock and called a "cog", is built. A sketch of a cog is shown in figure 2. At the cog the loader brushes one 4-foot length 12 feet wide, and another 4-foot length 16 feet wide to permit laying the switch and curve rails of the track into the roadway. The loader receives extra pay for this wide brushing and also for building the cog.

Back Brushing

Although the entries and roadways are originally brushed to approximately 6 1/2 feet above top of rail, gradual subsidence of the roof necessitates further brushing to obtain sufficient height for passage of animals used in haulage. This work is done by daymen.

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Roof Support and Control

The weight of the overburden is supported by the roadwalls, packwalls, and, to some extent, the gob. After the face advanced approximately 100 feet from the shaft pillar, a break in the roof usually occurred both at the pillar and at the face. The roof settled considerably at that time due to the weight of the overburden, and great care had to be taken to protect the entries and roadways. After the first break, as the face is advanced, breaks occur in the roof at varying distances. Sometimes they are several inches apart and sometimes the depth of the undercut (4 feet). The distance between the breaks usually depends upon the character of the roof, the packwalls, and the line of the face. As a rule the breaks at this mine do not extend any great distance up into the overburden. They have not been known to reach the surface. No doubt they are sealed by the thick stratum of shale in the overlying strata. The roof sometimes settles an amount equal to two-thirds the height of the opening before coming to rest, but the surface of the land does not appear to be damaged by this subsidence. For a discussion of subsidence in the northern Illinois field the reader is referred to Bulletin 238, Subsidence Due to Coal Mining in Illinois.[3]

Main haulageways are well-timbered, with crossbars set on approximately 4 1/2-foot centers with lagging placed over them.

Haulage

Cars are delivered to the roadways by a driver who serves six or seven places. Drivers haul trips of four or five cars from the roadways to the parting or storage tracks, where they are picked up by trolley locomotives and hauled in 25-car trips to the shaft bottom. There are three partings in this mine.

The capacity of the mine cars is approximately 2,400 pounds. Track gage is 41 inches.

Hoisting

The hoisting shaft, which is 400 feet deep, has three compartments - two for hoisting and one for air. Cars are cross-caged on the shaft bottom and placed on self-dumping cages. The hoist is electric-powered with a 300-horsepower a.c. motor.

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[3] Herbert, C. A. and Rutledge, J. J., Subsidence Due to Coal Mining in Illinois: Bull. 238, U.S. Bureau of Mines, 1927, 59 pp.

Ventilation

The air compartment of the hoisting shaft is the return or upcast airway in the ventilating system, and the hoisting compartments are downcast. The air travels from the shaft through the main entries to the face and after circling it returns to the air shaft and to the fan, which is located at this shaft. An escape shaft is situated approximately 200 feet from the main shaft.

Pumping

The only water in the mine is at the main shaft. It is gathered into a sump and delivered to the surface by a small electric pump.

Power

All power used in the mine is purchased from a public utility company. It is 2,200-volt, 60-cycle, a.c. current and is carried into the mine by a heavy armored cable to underground transformer stations. Current for mining machines is 220 volts a.c. For electric locomotives the a.c. current is converted to 250 volts d.c. by a 100-kv.-a. motor-generator set in the mine.

Tipple and Surface Plant

Coal is dumped from the cages into a weigh hopper in the tipple, weighed, and emptied onto shaking screens for sizing. When this plant was visited only two sizes of coal were being prepared - minus 2-inch and plus 2-inch. The minus 2-inch averaged about 24 percent of the output. From the screens the prepared coal goes to conveyors and is delivered to loading bins for trucks or to railroad cars.

Mine employees, based on production of 700 tons per day

Class	Number of men	Hours worked per day	Total man-hours	
Machine crews	9	7	63	
Motorman	1	7	7	
Drivers	16	7	112	
Trackmen	2	7	14	
Face boss	1	7	7	
Boss driver	1	7	7	
Main cagers	2	7	14	
Cager's helpers	3	7	21	
Greaser	1	7	7	
Mule feeder	1	7	7	
Roadmen (day)	14	7	98	
Roadmen (night)	5	7	35	
Mine examiner	1	7	7	
Safety engineer	1	7	7	
Total day-wage employees underground	58		406	
Loaders (by ton)	194	7	1,358	
Total men underground	252		1,764	1,764
Top employees				
Engineers	3	8	24	
Blacksmiths	2	7	14	
Bit sharpener	1	7	7	
Carpenter	1	7	7	
Topmen	8	7	56	
Weighman	1	7	7	
Watchman	1	7	7	
Total topmen	17		122	122
Total all employees	269			1,886

Summary

Class	Number of men	Total man-hours per day	Tons per man	Man-hours per ton per day
Loading	194	1,358	3.61	1.940
Back brushing	19	133	36.84	.190
Coal cutting	10	70	70.00	.100
Haulage and hoisting	27	192	25.92	.274
Miscellaneous underground	6	42	116.67	.060
Miscellaneous top	13	91	53.84	.130
Total	269	1,886	2.60	2.694

Deadwork and deficiencies are estimated at 6 percent of the total labor cost per working day.

This operation is an example of longwall mining, with individual roadways, using mining machines and hand loading.

Mine No. 2

Mine No. 2 is near Peru, Ill., and has an average daily production of 300 tons. Part of the output is used in the plant connected with this mine, and the remainder is sold locally.

The No. 2 coal seam, as correlated by the Illinois Geological Survey, is mined here. Locally it is called the Third vein. In this mine its average thickness is 42 inches. As a rule it is free from impurities and partings, but some small lenses of pyrite occur in the seam occasionally. The roof above the coal is a gray shale, called by the miners "soapstone", and black shale. In some places the black shale replaces the gray shale and lies on top of the coal. The bottom under the coal is a hard fireclay.

System of Mining

The system of mining followed in this mine is advancing longwall, with individual roadways, similar to that shown in figure 1.

Branch entries are turned to the right and to the left off the main entries at an angle of 45°. These entries are turned on approximately 225-foot centers along the main entries. Roadways are turned off the branch entries at a 45° angle toward the face. The distance between roadways at the face is usually 42 feet.

The mining practice differs from that in use at some mines in this field in that no undercutting machines are employed. The coal is undercut in the fireclay bottom under the coal by the loader (miner), using a pick. The usual depth of the undercut varies but in some places is only 2 to 6 inches. After undercutting to these shallow depths the coal is picked or wedged down for loading. (See fig. 2.) If the miner undercut 2 to 2 1/2 feet, it would be necessary for him to place sprags under the coal to prevent it from falling before he is ready to load. The shallow undercut saves labor of spragging and also time, but the picking and wedging of the coal produce smaller sizes.

The miner is paid by the ton for all coal loaded. The tonnage price includes the brushing of the entries and roadways and building the roadwalls and packwall along the face. The tonnage price also includes the labor of setting timbers along the face. These timbers are set approximately 2 1/2 to 3 feet from the face and on about 4-foot centers. There is one miner to each roadway.

Entry and Back Brushing

As the face advances, all entries and roadways are brushed in the roof to a depth of approximately 18 inches and a width of 8 feet. The rate of advance is very slow due to the practice of hand mining, and back brushing is only done after the roof has settled to a point where the passage of animals used in haulage is difficult. This roof settlement is slow, however. When necessary, the entries are rebrushed (back brushing) by a crew of roadmen, who also do other company work.

Roof Control and Support

The weight of the overburden is supported by the roadwalls and packwalls and the waste rock thrown into the gob. The worked-out area increases very slowly due to the method of mining in use at this mine, and the rate of subsidence is correspondingly slow. Breaks in the roof occur at irregular intervals but cause no particular problems. They have not been known to reach the surface, nor does the surface of the land appear to have been damaged.

Haulage

Cars are gathered with mules from the roadways and delivered to the partings or storage tracks. A 6-ton storage-battery locomotive pulls trips of 16 to 18 cars from the partings to the shaft bottom. The average capacity of each car is approximately 1 ton. Track gage is 36 inches.

Shaft Bottom

The capacity of the bottom is 30 to 40 cars. The cars are weighed on a platform scale before being caged. The tare weight of each car is shown on a metal plate attached to the car. The cars are cross-caged in hoisting.

Hoisting

The shaft is 360 feet deep and has two compartments for hoisting and one that serves as the airway.

The cars are placed on the cage, which is not of the self-dumping type, and hoisted by a 200-horsepower, a.c., electric hoist. In the tipple the cars are pulled off onto a platform by hand and dumped into a chute by means of a dumping cradle (gooseneck).

Ventilation

Ventilation is provided by a 6-foot high-speed fan driven by a 75-horsepower, a.c., electric motor. The fan is situated at the airway, which is upcast. The air passes down the hoisting compartments of the shaft, through the main entries to the face, and after circling it, through a return airway to the shaft.

An 8- by 8-foot auxiliary shaft equipped with a stairway serves as an escapeway.

Power

All power used about the mine is purchased from a public utility company. The alternating current is converted to direct current for charging the storage batteries on the haulage locomotive.

Tipple

After the coal is dumped from the mine cars into a chute, it goes onto shaking screens and is graded into sizes according to the market requirements. The following sizes have been made:

Inches	Grade	Percent
1 1/4	Screenings	20
1 1/4 by 2	Stoker	10
2 by 3	Do.	15
3 by 6	Egg	20
+ 6	Lump	35

Mine employees, based on production of 300 tons per day

Class	Number of men	Hours worked per day	Total man-hours	
Motorman	1	7	7	
Drivers	7	7	49	
Trapper and oiler	2	7	14	
Cager	1	7	7	
Car pusher	1	7	7	
Car coupler	1	7	7	
Weighman	1	7	7	
Tracklayer	1	7	7	
Timbermen	2	7	14	
Roadmen (brushing, etc.)	4	7	28	
Total day-wage employees underground	21		147	
Loaders (by ton)	114	7	798	
Total men underground	135		945	945
Top employees				
Engineers	2	8	16	
Dumpers	2	7	14	
Shakermen	3	7	21	
Rockmen	1	7	7	
Maintenance men	1	7	7	
Blacksmith	1	7	7	
Watchman	1	8	8	
Total topmen	11		80	80
Total all employees	146			1,025

Summary

Class	Number of men	Total man-hours per day	Tons per man	Man-hours per ton per day
Loading...........................	114	798	2.63	2.660
Brushing..........................	2	14	150.00	.047
Haulage and hoisting..............	17	121	17.65	.403
Miscellaneous underground.........	6	42	50.00	.140
Miscellaneous top.................	7	50	42.85	.167
Total.........................	146	1,025	2.06	3.417

This mine is an example of advancing longwall mining, with individual roadways using pick mining and hand loading.

The management is considering a change in the mining system now in use at this mine.

Mine No. 3

This mine is situated in the LaSalle-Peru area, and the output is used locally.

Only the system of mining as conducted in the No. 2 seam, using shaking conveyors along a longwall face, will be described. This system has been discontinued, but is of interest and worth describing because of the methods and practices employed and the difficulties encountered. Figure 3 is a sketch map showing the areas worked by this method.

The depth to the No. 2 seam was 428 feet, and the thickness averaged 36 inches. The roof was gray and black shale and the bottom a hard fireclay with some sandy shale.

Method Used in Area 1 (Fig. 3)

A pair of entries was driven south off the main west entry. The outside entry of this pair (one nearest the shaft) was brushed in the bottom. The inside entry was not brushed. A track was laid in the outside entry. The depth of the brushing was such that the top of a 5-ton car on this track was level with the bottom of the coal.

The first block was opened 200 feet long by 100 feet wide. A cut was made approximately 11 feet wide along the upper and lower sides of the block. These cuts were designated as 1st room east and 2d room east. (See figs. 3 and 4.)

In the 2d room east a double row of timber sets was placed on 3-foot centers along the length of the room. The sets in the upper half of the room used 7-foot caps, and those in the lower, 2-foot caps. The two rows of sets

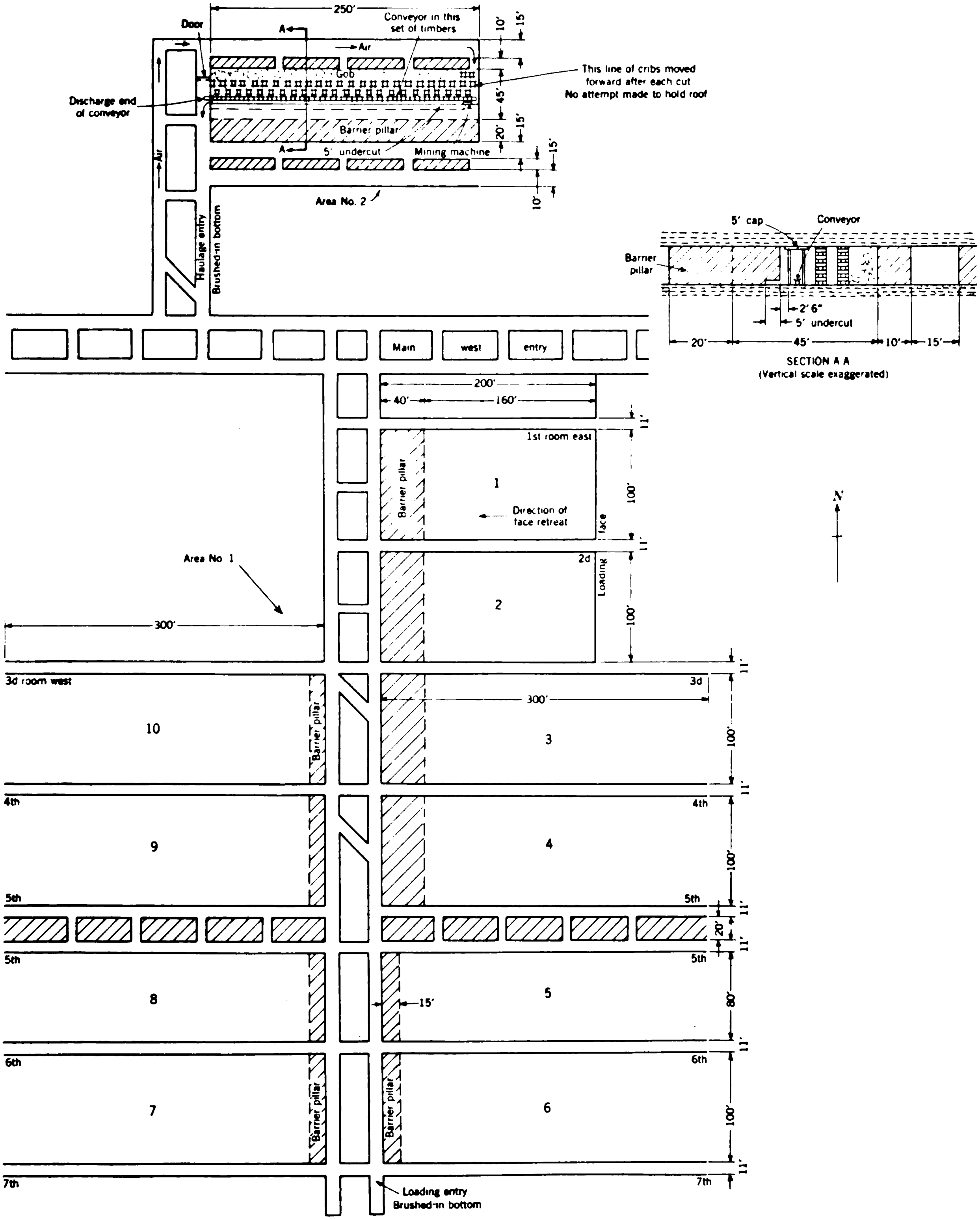

Figure 3.—Map of longwall mine showing development with shaking conveyors—northern Illinois area.

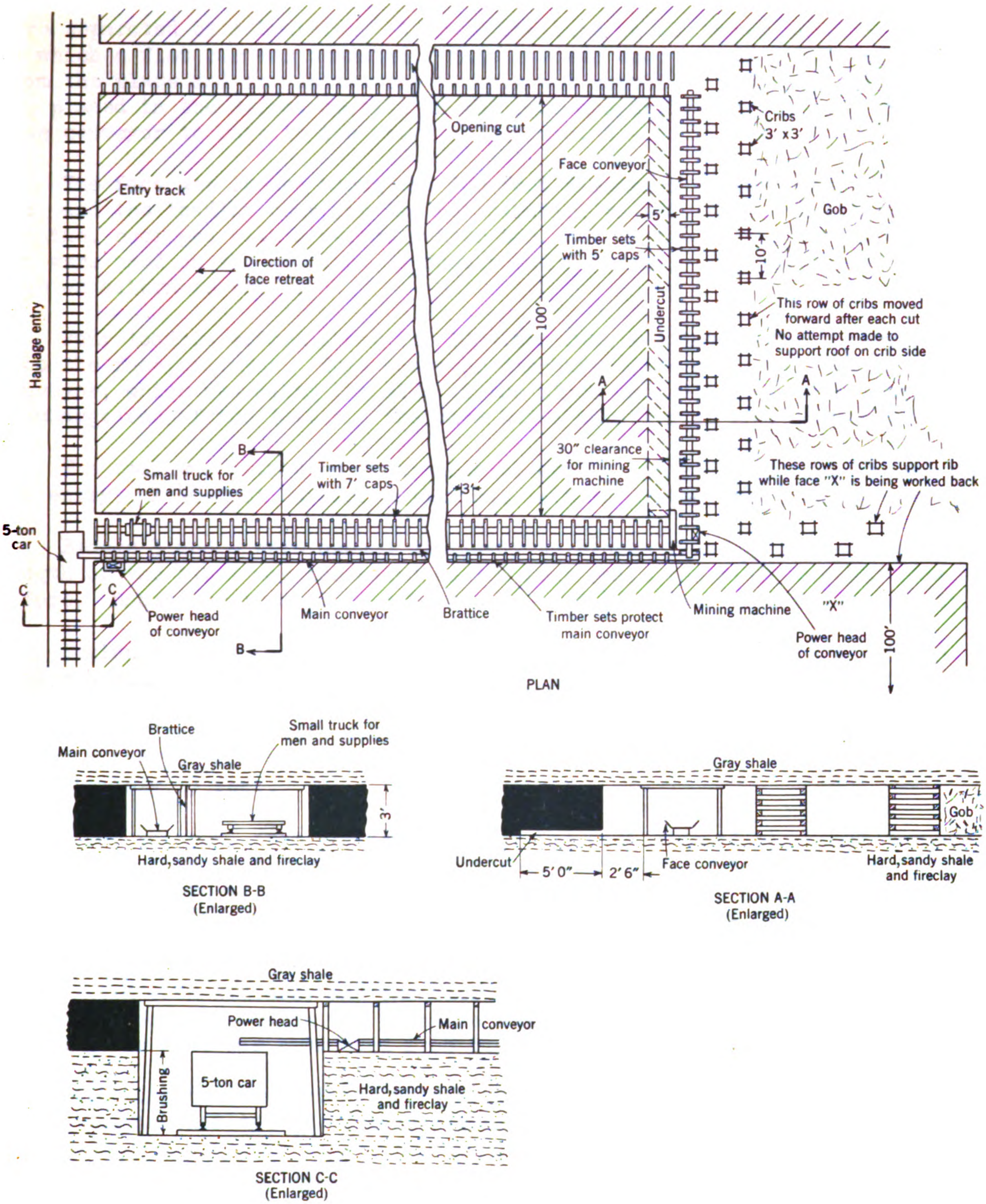

Figure 4.—Plan of first block in area No. 1 of longwall mine using shaking conveyors-northern Illinois.

were separated by a brattice. A track was laid in the upper section of the room on which a flat car was operated. This car was used by men for going to and from the place and for delivering timbers and supplies. The shaking conveyor was placed in the 2-foot section of the room and delivered the coal from the face conveyor to cars in the entry. (See sec. C - C, fig. 4.)

The face was opened along the 100-foot dimension of the block at the far end, and the loading conveyor was set parallel to this face. A longwall mining machine, equipped with a 5-foot cutter bar, cut in the bottom of the coal. Two men were used on the machine - a runner and a helper. The undercutting was done on alternate shifts.

Four loaders worked along the 100-foot face and loaded the undercut coal onto the face conveyor. This conveyor discharged the coal onto the 200-foot conveyor, which was along the side of the block and delivered it to cars at the discharge end of the latter. The cars had a capacity of approximately 5 tons.

The coal was extracted from these blocks, 1 and 2, to within 40 feet of the entry. A 40-foot barrier pillar was left to protect the loading entry.

Blocks 3 and 4 were opened similarly to blocks 1 and 2, except that the length of the block was increased to 300 feet while the width was 100 feet as before. Rooms, designated as 1st, 2d, 3d, and 4th east, were driven singly.

Beginning with blocks 5 and 6, a 20-foot coal pillar was left between blocks 4 and 5, and block 5 was opened 80 feet wide with a cut along the upper side of the block, as in the other blocks described. Block 6 was opened 100 feet wide. Crosscuts were made at 60-foot intervals through the pillar between blocks 4 and 5. The barrier pillar along the haulage entry was reduced to approximately 15 feet.

After the coal from blocks 1 to 6 on the east side of the haulage entry was extracted the 7th room west was driven, and blocks 7 to 10 were opened. (Fig. 3.) Before all of the coal could be mined from blocks 8 and 9, it became difficult to control the roof, and some coal was lost in these blocks. Breaks in the roof occurred approximately 30 feet apart, and they extended the width of the face. The weight of the overburden between these breaks could not be held with timbers, and the roof fell at the face. It appeared that after the roof was broken the pressure was relieved temporarily, and practically all the coal was extracted from block 10.

Following that experience this part of the mine was abandoned for the time being, and another system of longwall mining was tried in area 2.

Method Used in Area 2 (Fig. 3)

A pair of entries were driven north off the main west entry. The outside entry of this pair was brushed in the bottom deep enough so that the top of a 5-ton car would be level with the bottom of the coal.

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A cut 15 feet wide and 250 feet long was made at right angles to the entry and served as the air course of the panel face. A 10-foot pillar was left and another cut 15 feet wide made parallel to the first cut and 250 feet long. Crosscuts were put through 60 feet apart between the two cuts. The second or outside cut was the start of the longwall face. A longwall mining machine equipped with a 5-foot cutter bar cut in the coal at the bottom of the seam. The cutting was done at night. Two men, a runner and a helper, operated the cutting machine.

The shaking conveyor was installed along the 250-foot face. The position of the conveyor and method of timbering are shown in section A - A (fig. 3). The undercut coal was placed on the conveyor by 10 loaders and delivered to 5-ton cars in the entry at the discharge end of the conveyor. Approximately 150 tons of coal were loaded from each cut by the 10 loaders in a 7-hour shift. After the loading was completed, another crew of 6 men moved the 250 feet of conveyor ahead one cut and erected timbers and cribs. Two rows of cribs protected the conveyor, and the row nearest the gob was taken out and reset ahead after each cut or face advance.

The face crew of this panel consisted of the following men:

1 machine crew - 2 men
10 loaders
6 men to move conveyor and timber
1 locomotive engineer
1 man at conveyor head
20 men - total for the unit, which produced approximately
150 tons or 7.5 tons per man

Difficulty again developed in supporting the roof at the face, and this system was discontinued. It was found that breaks in the overlying strata occurred at the barrier pillar and at the face about every 30 feet of face advance and for the entire length of the face. The weight of this block of overburden, 30 feet wide by 250 feet long, could not be successfully supported. The timbers and ultimately the pillars would be crushed.

For the present, longwall mining, using undercutting machines and loading on shaking conveyors along the face, has been discontinued for the following reasons:

1. The large amount of development necessary before coal can be recovered.
2. The irregular grades encountered in the mine.
3. The difficulty in supporting the roof on timber cribs.
4. The heaving bottom brought about by subsidence of the overburden.
5. The large percentage of time lost in moving the entire conveyor and drive unit every cut.

At present two sections of the mine are being developed on an advancing-longwall system, using individual roadways. Undercutting is done with a longwall mining machine equipped with a 4-foot cutter bar and operated by three men. Loading is done by hand. Since the system of mining is undergoing changes and experiments, details of the operation will not be summarized.

CENTRAL ILLINOIS AREA

The locality visited is in the neighborhood of Decatur, Macon County.

The topography is flat to rolling.

General Geology

The coal seam mined in the operation described was the No. 5, as correlated by the Illinois Geological Survey. The seam averages 4 feet 6 inches in thickness and shows fine laminations with "mother-coal" partings. At some places there are discontinuous bands of pyrite near the middle of the seam. Clay seams or "horsebacks" extend from the floor through the coal seam into the roof at frequent intervals and appear to be a distinguishing feature of the No. 5 seam.

The immediate roof of the coal is 2 feet to 2 feet 6 inches of a black, sheety shale called "black slate" by the miners. Above the black slate is a hard, heavy band rock, averaging 10 inches in thickness.

The bottom is fireclay containing nodules of pyrite. In some places this bottom heaves when wet.

Mine No. 4

Mine No. 4 is near Decatur and has loading facilities for both railroad and truck trade. The daily production varies according to the demand; on the day the mine was visited the output was 1,200 tons. The number of employees is regulated to obtain the required output.

The main shaft is 600 feet deep and has two compartments, which are used for hoisting; this shaft is the upcast airway of the ventilating system. The air shaft also has two compartments, one for air and the other for a miners' escapeway, and is equipped with a stairway. The air shaft is the downcast and is heated by steam radiators between the fan and the shaft.

System of mining

Three methods of mining are used in this mine:

1. Advancing longwall, with individual roadways.
2. Room-and-pillar in a small section of the mine.
3. Advancing longwall, using shaking conveyors, along a 750-foot face between two individual-roadway longwall sections.

The first and third of these will be described.

This mine is developed similarly to that shown in figure 1. Branch entries are turned both to the right and to the left off the main entries at 45° and at 225-foot centers along the main entries. Individual roadways are turned at 45° toward the face off the branch entries. The center line between roadways at the face is approximately 42 feet.

Cutting

Longwall mining machines with 4-foot cutter bars cut in the bottom fireclay under the coal. One machine cuts an average of 250 to 275 feet in a 7-hour shift. The cutting is done at night, and each machine is operated by two men, a runner and helper. The helper sets props back of the machine as it cuts across the face and sprags the coal. The machine cuttings are shoveled into the gob by the miner, and this work is included in the tonnage price paid him for all coal loaded.

The average number of employees for each mining machine is approximately:

20 loaders
2 back brushers
2 drivers

There is approximately 1 tracklayer for every 3 machines.

Longwall operations are divided into four sections, as follows:

1. 2 machines and 46 loaders.
2. Do.
3. 2 machines and 35 hand loaders and the conveyor section.
4. 3 machines and 68 loaders.

Loading

There are usually two loaders in each roadway, and these move to another roadway after completing their work in the first roadway. Each two loaders are entitled to two roadways. Besides loading the undercut coal, the loader brushes the roadway to a depth of 24 inches above the top of the coal. The width of the brushing at the top of the coal is 10 feet and at the top of the brushing 7 feet. Roadwalls and packwalls, locally called "packs", are built by the loader from the brushing rock. Brushing and stowing are included in the tonnage price paid the miner, except where the loader is working in an entry; in that case, he is paid an additional rate for this work.

After loading the undercut coal, the loader sets a line of props approximately 30 to 36 inches from the solid coal face on about 3 1/2-foot centers. The props, which average 4 feet 6 inches in length, with a minimum diameter of 4 inches, are set with a toe-in at the top.

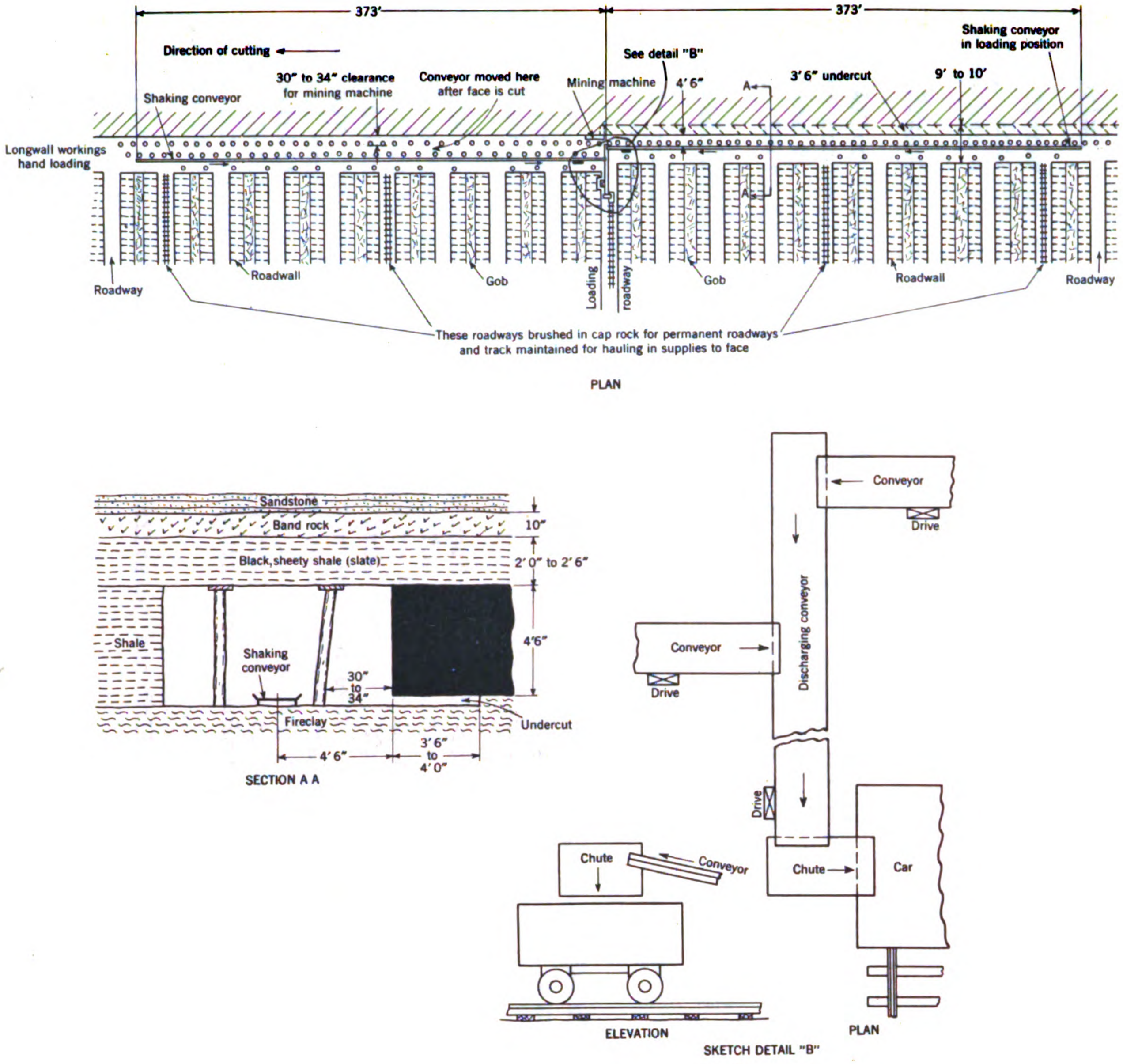

Figure 5.—Sketch of longwall face using conveyors—central Illinois area.

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Horsebacks, which are encountered frequently, are paid for as a deficiency to both the loader and machine crew. Cogs at the roadway turn are usually built by the loader. There is a specified price for this work. The loader receives all the extra pay for making roadway turn. Additional width of brushing is required at each new roadway turn.

Timbering

Timbering of main entries is maintained by two men, who also do trackwork. Entries are timbered 6 to 6 1/2 feet in the clear, with a set of two posts and a cap having mortised joints.

Back Brushing

After the roof has settled, due to the weight of the overburden acting on the roadwalls and packs, it is necessary to rebrush the entries. Back brushing is done by daymen. In some cases the brushing must be drilled and shot. There is usually one hand-drilling machine to each mining machine.

Conveyor Section

A type of shaking conveyor made in 10-foot sections in used, and the width of the pan at the top is 22 inches.

The conveyor units are in two sections, each 373 feet long. Each conveyor discharges to a central conveyor, which discharges into mine cars on the roadhead. (See fig. 5 for sketch of system used.)

The same system of individual roadways at 42-foot centers off entries at 45° is used as in hand loading. The roadways are brushed to the hard cap rock. This brushing ranges from 24 to 30 inches in thickness. The rock from the brushing is used for walls and back filling. No track is laid in the roadways, except at the center of the two conveyors for loading and at the end and center roadways of each conveyor. These roadways are back-brushed and maintained at full height and 10 feet in width; they furnish rock for the 12 by 12-foot rock packs, which are built at the corner of each heading, for every cut of advance. Track is laid in these roadways for delivering supplies to the face.

The conveyor-section crew consists of the following:

7	loaders.
7	brushers.
2	men at discharge end of conveyor. These men also do the electrical work occasioned by the moving of the conveyor.
1	driver.
2	machinemen
1	prop setter
20	men - total

The coal face in the conveyor section is approximately 750 feet long. One cutting-machine crew will cut 373 feet of face in 15 to 16 hours. Seven loaders load the coal from 373 feet of face, which averages approximately 200 tons, in 9 to 10 hours. The loaders, however, only work 7 hours and load approximately 135 tons. Each man loads 50 to 60 feet of face. When all the coal from the cut is loaded, the conveyor is moved ahead approximately 3 1/2 feet.

The advantages claimed for the conveyor are that it

1. Eliminates back brushing in all but five roadways.
2. Eliminates track laying in all but five roadways.
3. Improves haulage by taking coal to one point for loading.
4. Saves heavy timbering in haulageways.

Roof Control and Support

The weight of the overburden is supported by the roadwalls and packwalls, and by the machine cuttings, horseback material, and other impurities that have been thrown into the gob. The undercut coal is broken off at the back of the undercut by the weight of the overlying strata. Breaks in the roof usually occur at 3 1/2 to 4 feet - the depth of the cut - but do not appear to extend upward to any appreciable height.

Where conveyors are used, the method of roof support is the same as for hand loading, and although the face has been advanced approximately 80 feet since the introduction of conveyors, no change has been noticed in the working condition of the roof.

The damage to the surface was not noticeable from the longwall operation at this mine.

Haulage

Gathering to partings is by mule, usually in 4-car trips.

From the partings to the shaft the cars are hauled by electric locomotives in 26- to 28-car trips. Cars average 3,000 pounds capacity and track gage, 38 inches.

Hoisting

The hoist is 20 by 36 inches, with an 8-foot drum. Cages are self-dumping. The bottom is equipped with an automatic caging device for dropping the loads and handling empties after they are pushed off the cage by the loads.

Power

Hoisting is with steam, but all other power is 60-cycle, a.c. current, which is purchased. The power for mining machines is stepped down to 240 volts by a transformer.

Tipple and Surface Plant

The tipple is equipped with two sets of shaking screens; one prepares coal for loading into railroad cars and the other for truck and local trade.

Sizes of coal made:

Inches	Grade	Percent
1/2 by 1 1/4	Chestnut	3
1 1/4 by 1 7/8	Stoker	27
1 7/8 by 2	Nut	7
2 by 6	Egg	25
6	Lump	38

Mine employees, based on production of 1,000 tons per day from longwall operations

Class	Number of men	Hours worked per day	Total man-hours	
Cager	1	Ave. 11.0	11.0	
Empty puller and greaser	1	7.5	7.5	
Spragger	1	7.5	7.5	
Coupler and oiler	1	7.5	7.5	
Mule tender	1	7.0	7.0	
Electricians (day)	2	8.0	16.0	
Electrician (night)	1	8.0	8.0	
Track and timbermen	2	7.0	14.0	
Mine examiner	1	7.0	7.0	
Motormen	3	7.5	22.5	
Back brushers	16	7.0	112.0	
Drivers	16	7.5	120.0	
Tracklayers	3	7.0	21.0	
Face bosses	4	7.0	28.0	
Conveyor section				
Loaders	7	7.0	49.0	
Brushers	7	7.0	49.0	
Electricians	2	7.0	14.0	
Drivers	1	7.5	7.5	
Machinemen (1 crew)	2	7.0	14.0	
Prop setter	1	7.0	7.0	
Total daymen underground	73		529.5	529.5
Machinemen (8 crews) by ton	16	7.0	112.0	
Loaders - by ton	195	7.0	1,365.0	
			1,477.0	1,477.0
Total men underground	284			2,006.5

Mine employees, based on production of 1,000 tons per day from longwall operations - Continued

Class	Number of men	Hours worked per day	Total man-hours	
Top employees				
Engineers	4	6.0	24.0	
Fireman	1	7.0	7.0	
Oiler	1	8.0	8.0	
Blacksmith	1	7.0	7.0	
Blacksmith helper and car repairer	1	7.0	7.0	
Top cager	1	9.0	9.0	
Trucker	1	13.5	13.5	
Topmen	3	7.0	21.0	
Top boss	1	7.0	7.0	
Dock boss	1	7.0	7.0	
Weighman	1	7.0	7.0	
Watchman	1	7.0	7.0	
Total topmen	17		124.5	124.5
Grand total	301			2,131.0

Summary

Class	Number of men	Total man-hours per day	Tons per man per day	Man-hours per ton per day
Loading	202	1,414.0	4.95	1.414
Back brushing	23	161.0	43.48	.161
Coal cutting	21	150.0	47.62	.150
Haulage and hoisting	33	245.5	30.33	.246
Miscellaneous underground	12	84.0	83.33	.084
Miscellaneous top	10	76.5	100.00	.076
Total	301	2,131.0	3.32	2.131

Deadwork cost is estimated at 7 percent of total labor cost per working day.

This mine is an example of longwall mining in a seam of coal averaging 4 feet 6 inches, with considerable horseback in the seam.

NORTHEAST KANSAS - LEAVENWORTH COUNTY

The area visited is near Leavenworth and adjacent to the Missouri River. The topography is very rough.

The coal seam mined has been correlated by the Missouri Bureau of Geology and Mines as the Bevier of Missouri. It lies approximately 100 feet below the top of the Cherokee shales of the Pennsylvania system.

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The seam in the mine visited averages 22 inches in thickness, is clean with no partings, and is a bituminous coal of good quality. The roof above the coal is a hard, gray shale but breaks easily when mined with a pick. In some instances there are lenses of impure limestone called "sulphur rock", which replace the shale roof. This ranges from 3 inches to 3 feet in thickness.

The bottom under the coal is fireclay, which averages 24 inches in thickness. At places the fireclay is replaced by a hard shale.

Mine No. 5

Mine No. 5 is near Leavenworth and adjacent to the Missouri River. At present the average daily production is 250 tons. The output is sold commercially and shipped both in railroad cars and trucks. The market for the coal is limited.

The depth to the coal is 720 feet. The main hoisting shaft has three compartments - two hoisting and one air. The air compartment is the upcast airway, and the hoisting compartments are downcast. The escapeway from the mine (the shaft of an abandoned mine approximately 1 mile from the hoisting shaft), is equipped with a hoist, and there is an engineer on duty during the day and two watchmen at night, each on 8-hour shifts.

This mine generates some gas.

System of Mining

Advancing longwall, using individual roadways, is the system used in this mine. In a general way it follows the plan of development employed in other mines using this system, except that the branch entries are turned at 65° instead of 45°. Main entries were driven each way from the shaft. From these main entries branch entries, driven at an angle of 65°, were turned to the right and to the left on 275-foot centers along the main entries. From the branch entries, the roadways were turned off at an angle of 65° toward the face. The distance between center lines of the roadways averaged 50 feet at the face. The maximum length of roadways was 275 feet. The roadways were cut off by the next cross entry from the main entry.

The roadways were brushed in the roof to a height of 5 feet above the top of the rail. Miners did this brushing at a certain price per yard for shale roof and a higher price for sulphur rock. The roof, although a hard shale, can be taken down with picks. No explosives are necessary, except in the "sulphur rock."

The entries were brushed 6 feet wide and to 6 feet above top of rail.

The brushing is used to build the roadwalls and packwalls along the face. Excess brushing beyond that required for this purpose and for filling the gob is loaded on cars, taken to the shaft, hoisted, and dumped into the rock chute. From there it goes to the rock car and is hoisted over an incline to the top of the rock dump for final disposal.

Cutting

Four longwall mining machines, equipped with 2 1/2-foot cutter bars, operate two and sometimes three 8-hour shifts, depending upon the demand for coal. Four men, a runner and three helpers or shovelers, work on each machine. The machines cut in the fireclay under the coal and follow one another around the face, which is in the form of an arc. Each machine cuts an average of 300 feet in an 8-hour shift.

The helpers shovel all machine cuttings into the gob and set props, on approximately 2- to 3-foot centers, along the face after the machine has passed. The props support any loose roof shale. The helpers also place sprags in the cut beneath the coal to support the coal until the machine has passed and the cuttings are put into the gob. The last shoveler knocks out the sprags, and the coal falls.

Loading

There are approximately 75 men loading behind machines and 25 cutting and loading by hand. One man works in each roadhead and loads out the coal between his roadhead and the next. His working place is approximately 50 feet long. The coal is loaded on flat boxes with small wheels, called "buggies", and pulled along on light rails made up in 8-foot sections to the roadway where the coal is placed on cars. The buggies are used to facilitate bringing coal to the cars. The capacity of the buggies varies, depending upon the ability of the loader to pull them along the face. Loaders, in addition to loading the coal, brush the roadways, for which they are paid extra. Loaders behind machines average about 3 tons per man.

Hand mining is done in a small section of the mine, the coal being undercut with picks. The fireclay is dug out under the coal to varying depths, depending upon the ease with which the coal falls. The hand miners also brush the roadways, and, for which work they are paid extra. The average output for hand-loading and pick-mining is approximately 2 tons per man.

Roof Control and Support

The shale roof above the coal is good but will not bend from the weight of the overburden when the coal is undercut. It usually breaks at the back of the undercut. The packwall and gob line are built approximately 4 feet from the face to carry the weight. Props are set between the gob line and the face to support the roof temporarily.

Roadwalls are built solid along the sides of the roadways and entries and extend from the fireclay bottom to the roof shale. The weight of the overburden is carried on these walls and the gob. The gob is composed of all fireclay cuttings and slabs of roof that have fallen.

After the coal is undercut either by machine or hand, the weight of the overburden acting on the unsupported face of coal causes the coal to break off and fall. The full weight of the overburden appears to come onto the packwalls and gob about 40 to 50 feet back from the face. Six-foot entries are decreased in height, sometimes as much as one third the height of the opening. Subsidence is generally about 1 foot. Back brushing of the entries is then necessary.

Breaks in the roof do not apparently continue to the surface. The average depth to the coal is 720 feet, and there appears to be little or no surface subsidence from the mining of this 22-inch seam. Part of the workings are under the Missouri River, and no surface water has ever been known to enter the mine from that source.

Haulage

The cars are loaded at each roadway by the loader and pushed to the roadway switch on the entry. The cars are gathered from the roadway switch, by a trolley locomotive. Two 5-ton locomotives are in use in the mine. Each gathers cars from two entries and pulls an average of 25 cars per trip to the shaft.

The cars have an average capacity of 2,800 pounds. Track gage is 30 inches. There is no animal haulage in the mine.

Shaft Bottom

The bottom is arranged with double track for storage of loads and empties. Cars are cross-caged; caging is done from both sides of the shaft. A run-around track passes around the shaft, and cars can be transferred from one side to the other without passing over the cages.

Hoisting

Cars are hoisted on self-dumping cages, and the coal is dumped into the weigh hopper in the tipple. A 24- by 36-inch steam hoist with a 10-foot drum is used for hoisting.

Ventilation

The mine generates some gas, and close inspection of the workings is maintained at all times by two firebosses (gasmen). Ventilation is provided by a steam-operated fan of the paddle-wheel type.

Power

Electric power for mining machines and haulage is purchased from a power company and is 2,200-volts, a.c., 60-cycle current. The alternating current is converted to direct current for the trolley locomotives with a motor-generator set. Current for the mining machines is stepped down to 220 volts a.c. by transformers in the mine.

Tipple and Surface Plant

The head frame and tipple are of wood.

The tipple is equipped with shaking screens. When the mine was visited only two sizes of coal were being prepared:

Inches	Percent
-3 1/2	33
+3 1/2	67

The prepared coal is loaded into railroad cars or trucks, depending upon the demand.

Mine employees, based on production of 250 tons per day

Class	Number of men	Hours worked per day	Total man-hours per day	
Cagers..........................	2	8.5	17.0	
Load dropper....................	1	8	8	
Motormen........................	2	8	16	
Trip riders.....................	2	8	16	
Firebosses (gasmen).............	2	8	16	
Water bailer....................	1	8	8	
4 machine crews (day)...........	16	8	128	
4 machine crews (night).........	16	8	128	
Machinist.......................	1	8	8	
Mine foreman....................	1	8	8	
Total day employees underground	44		353	
Loaders behind machines (by ton).	75	8	600	
Loaders, hand (by ton)..........	25	8	200	
Total underground...............	144		1,153	1,153

Mine employees, based on production of 250 tons per day - Continued

Class	Number of men	Hours worked per day	Total man-hours per day	
Top employees				
Engineers........................	2	9	18	
Engineer (at escapeway)..........	1	9	9	
Fireman..........................	1	8	8	
Weighman.........................	1	8	8	
Blacksmith.......................	1	8	8	
Blacksmith helper................	1	8	8	
Car repairer.....................	1	8	8	
Car trimmer......................	1	8	8	
Dirt-disposal engineer...........	1	8	8	
Local coal-chuteman..............	1	8	8	
Night watchman...................	1	8	8	
Night watchman at escapeway......	2	8	16	
Total top employees............	14		115	115
Total all employees............	158			1,268

Summary

Class	Number of men	Total man-hours per day	Tons per man per day	Man-hours per ton per day
Loading....................	100	800	2.50	3.200
Coal cutting...............	33	264	7.57	1.056
Haulage and hoisting......	10	83	25.00	.332
Miscellaneous underground.	4	32	62.50	.128
Miscellaneous top.........	11	89	22.72	.356
Total................	158	1,268	1.58	5.072

Deadwork cost is estimated at 5 1/2 percent of total labor cost per working day.

This mine is an example of working a thin seam of coal (22 inches) at considerable depth (720 feet), using longwall mining with individual roadways.

WESTERN MISSOURI - LAFAYETTE AND RAY COUNTIES

General Description of District

The area is hilly, with high bluffs bordering the Missouri River. Although the Lexington coal seam, which is mined extensively in this area, lies comparatively level, the depth from the surface varies considerably due to the surface topography.

The Missouri Pacific, Chicago & Alton, and Chicago, Milwaukee, St. Paul & Pacific Railroads serve the mines in these counties.

General Geology

The Lexington coal seam is one of the most persistent beds in this area. It varies in thickness, averaging 18 to 20 inches. Geologically it is just below the top of the Cherokee shales which comprise the lowest member of the Pennsylvanian in this area. It has been correlated by the Missouri Bureau of Geology and Mines as the same bed stratigraphically as the Mystic seam in Iowa.

The coal is hard and bright, and is distinguished by white gypsum scale on the quadrangular cleavage joints, which are well-developed.

A section of the seam and of its under and overlying strata is shown in figure 6.

Immediately above the coal is a block slate 8 to 12 inches thick, then a roof slate 2 to 6 inches thick, and then the cap rock, a hard limestone.

The coal seam is divided by a clay parting up to 1/2 inch thick, and the top coal is 15 to 17 inches thick. Below the parting the bottom coal averages 4 inches in thickness.

Below the bottom coal is a band of pyrite, fireclay, and limestone of varying thickness but averaging 1 1/2 inches; then a hard rock containing pyrite, called "sulphur rock", which ranges in thickness from 1 1/2 to 8 inches; then fireclay 0 to 24 inches in thickness; then a hard, blue limestone, the bottom rock.

A typical geological section in this area is as follows:

	Thickness		Depth	
	Feet	Inches	Feet	Inches
Clay and gravel................	55		55	
Shale, yellow..................	12	6	67	6
Limestone, white...............	7		74	6
Shale, yellow..................	17	4	91	10
Limestone, white...............	12	1	103	11
Shale, black...................		6	104	5
Limestone, cap rock............	7	8	112	1
Shale, black...................		10	112	11
Coal (Lexington)...............	1	9	114	8
"Sulphur"		6	115	2
Clay to limestone bottom rock..	4		119	2

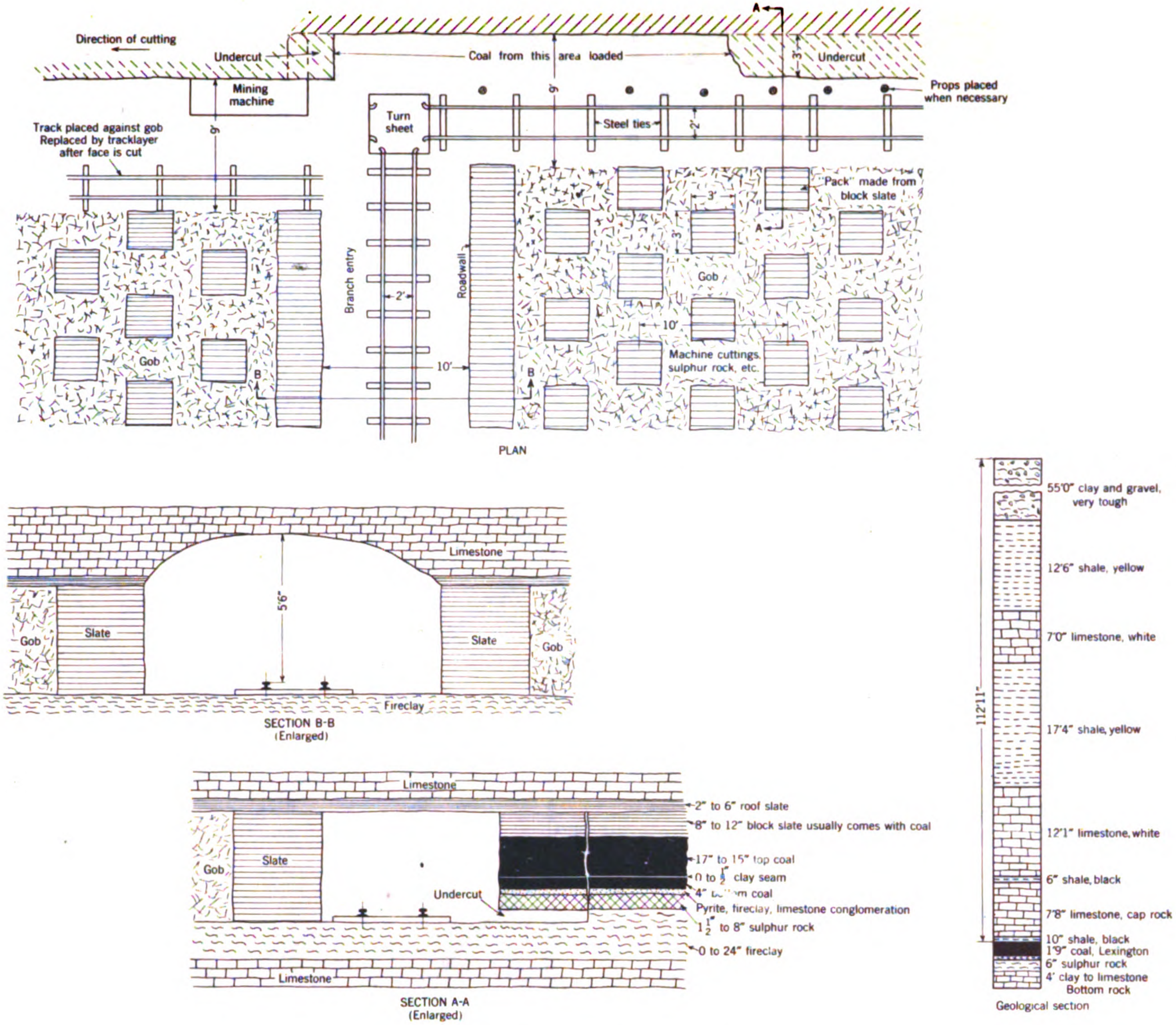

Figure 6.–Sketch of portion of face in longwall mine using face track–Lexington (Mo.) area.

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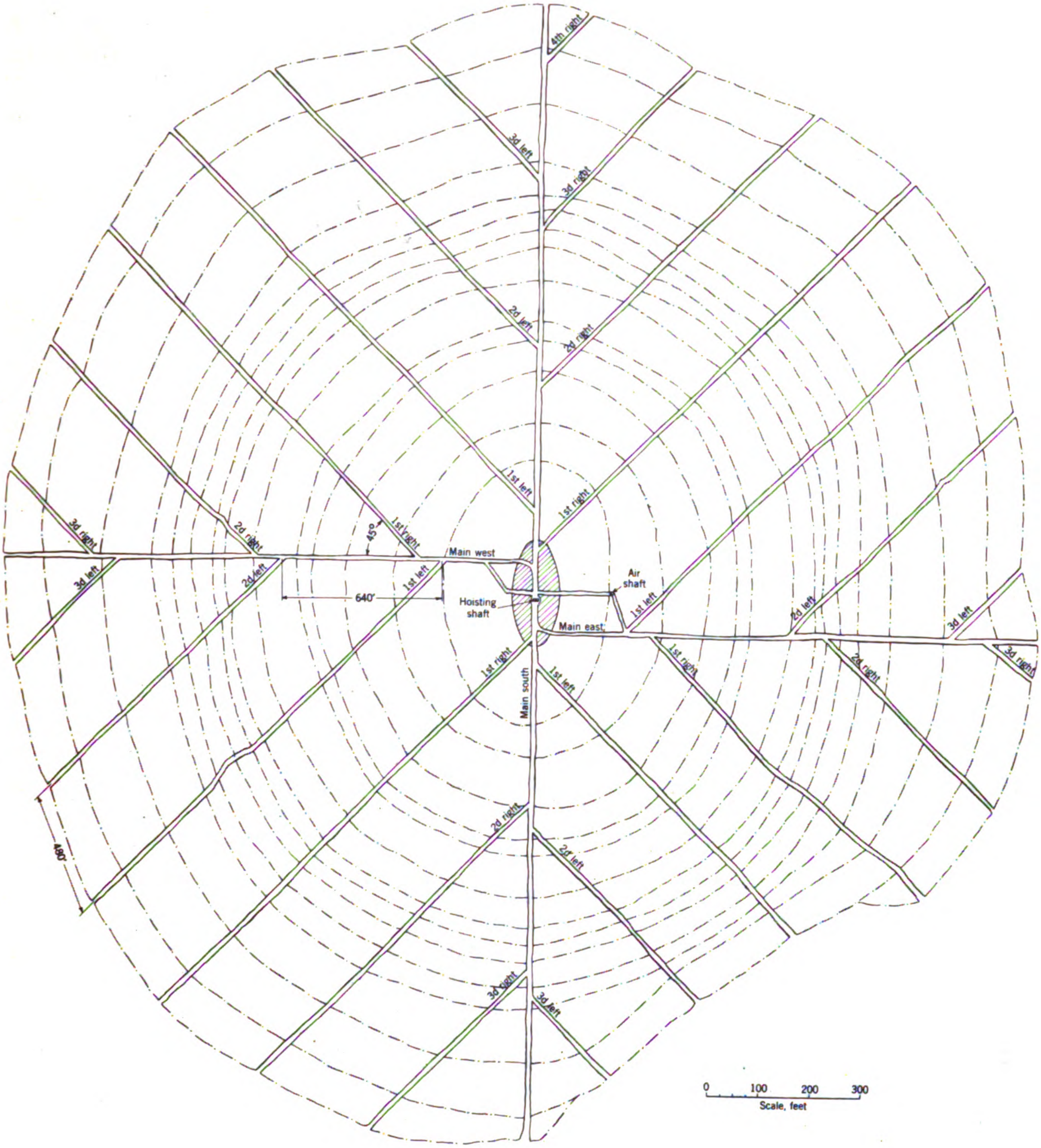

Figure 7.—Map of longwall mine-face track – Lexington (Mo.) area.

Mine No. 6

This mine is near Lexington and has railroad connections. The average daily production is 530 tons in a 7-hour shift. The output is shipped for railroad fuel. The coal, which comes from the mine in large blocks due to the mining method employed, is crushed to 4-inch size for convenience in firing locomotives.

The main shaft has two compartments for hoisting and one for a manway and is 180 feet deep. This shaft is the upcast whereas the air shaft is the downcast. Ventilation is provided by a 14-foot paddle-wheel fan.

Steam for hoisting, fan, and electric power generation is furnished by three 72-inch by 18-foot horizontal return tubular boilers, which are hand-fired. All electric power is 250 volts, d.c., and is used for operating coal-cutting machines.

System of Mining

Advancing longwall using a face track is the system of mining used. Refer to figure 7, which is a map showing the development of a mine according to this system.

The average thickness of the seam is 18 inches, and a section is shown in the sketch, figure 6, section A - A.

After the shaft was sunk, a pillar of coal was left to protect it and the bottom. Main entries were driven through this pillar toward the property lines. Off these main entries other branch entries were driven, turned at 45° both to the right and to the left from the main entries on 640-foot centers. The distance between branch entries at the face is 480 feet or 24 rail-lengths. These entries are brushed in the limestone cap rock or in fireclay bottom so that the height of the entries is 5 1/2 feet above top of rail.

The entries are brushed at night by three crews of two men each (six men); there is also one driller and one driver for the three crews. One vertical hole is drilled every 4 1/2 feet with a compressed-air stoper-type drill in the center of the entry. These holes are shot with 40-percent dynamite, and the rock is loaded on cars and then taken to the bottom for hoisting. Rock is hoisted at night and dumped into a rock chute. From there it goes to a rock car and is hoisted over an incline to the top of the rock dump for final disposal. This limestone rock is sometimes crushed and used for road-building material.

All the brushing is not taken from the top. As much as possible of the fireclay below the coal is lifted, and the balance of brushing is taken from the limestone top.

Cutting

In this mine five longwall mining machines equipped with 3-foot cutter bars operate two 7-hour shifts each per day. Three men work on each machine - a runner and two helpers. Cutting is done in the fireclay under the sulphur rock. The "kerf" or undercut is 5 to 8 inches high. The machines follow one another around the face, which is in the form of an arc. Each machine will cut an average of 450 feet per shift or 25 rail-lengths.

The track, which extends around the face, is of 12-pound rail on light steel ties. To permit passage of the cutting machine it is disconnected in 40-foot sections and turned up on edge against the gob.

The two shovelers or helpers clean up all machine cuttings and shovel them into the gob; also, they set props under any bad piece of roof.

At the end of each shift the machine crews leave a report of the places and footage cut in each place.

Loading

Tracklayers go to the parts of the mine where cutting has been completed and move the track ahead the width of the cut (3 feet), then replace and recouple the track so that the place is ready for the loader.

The loader, on entering his working place and after examining the roof and finding it safe, or making it so by placing props, begins taking the block slate off the coal. The coal in coming down rolls over and makes the block slate accessible. This block slate is split into large blocks with a pick and is removed from the coal. With these blocks of slate are built rock pillars (packs) approximately 3 feet square and roughly on 10-foot centers along the face and two cuts (6 feet) from the broken coal face. These pillars or packwalls extend from the fireclay bottom to the roof slate. Each loader has 3 to 4 rail-lengths of face (60 to 80 feet) as his working place, and he builds the packwalls as he proceeds along the face. All rock in excess of that required for building them is thrown into the gob back of the pack line.

A solid packwall (the roadwall) is built along each side of the entry. The width between walls is usually 10 feet. The rock packwalls are staggered along the line of the face as it advances. (See fig. 6.)

After cleaning the block slate off the coal, the loader proceeds to load his coal on cars. These cars are flat but have a low side board and wing on each side. The clay seam, sulphur rock, and other impurities are thrown into the gob. The loader must leave his place in such condition that it is ready for the machine crew, except for removal of the track.

There are times when the block slate adheres to the roof slate; then it must be wedged down. Sometimes the roof slate comes down with the block slate.

Various "deficiencies" are defined in the contract with the loader, for which he is paid extra. These include tight block slate, which does not fall with the coal and must be wedged down; cleaning up roof slate which falls; loading fireclay from the bottom if the bottom of the undercut is over 8 inches from the sulphur rock; falls of cap rock, when not occasioned by improper workmanship of the miner; and other unusual conditions over which the loader has no control.

The loader is paid on a tonnage basis, including allowances for wheeling (pushing the car from the loading place at the face to the parting where empty cars are received). The maximum distance to this point is set at 250 feet.

Roof Support and Control

The limestone cap rock in this mine is exceptionally good. Because of its characteristic bending instead of breaking, it is particularly adapted to the longwall method of mining, using face track. The average unsupported distance from the line of the packs and gob to the face is 3 cuts (9 feet). Timbers are used only when necessary to support the roof slate along the face or when the cap rock breaks on the face.

The full weight of the overburden appears to come onto the packs and gob about 40 feet back from the face. The entries are not brushed until settlement of the roof is completed. Breaks in the cap rock occur at times, but this is exceptional in this mine. If the break reaches the surface, it usually shows ahead of the face line at a distance that depends upon the depth of the coal. These breaks soon seal themselves.

After the coal has been undercut the weight of the overburden acting on the cap rock bends the latter and causes the coal to break off at the end of the cut so that it falls and rolls over. Settling of the roof is noticeable soon after the coal is down. The rock pillars (packs) soon show that they have taken weight.

Haulage

At the head of each entry at the face is a turntable, (flat sheet); the track from the entry and from the face both lead to it. Both loads and empties are turned at this point. (See fig. 6.)

All entries are single track, and trips averaging six cars (boxes) are hauled by mules from the receiving point to the shaft bottom. The track gage is 24 inches. There are few, if any, partings or storage tracks.

Shaft Bottom

The mine has a two-sided shaft bottom. Cars are caged from both sides of the shaft and empties taken from both sides. There are no mechanical or gravity loading aids. The loads are placed on a center track leading to the cage, and the empties are switched to storage tracks alongside the center track for loads.

Hoisting

The cars are hoisted on self-dumping cages, and the coal is dumped into a weigh hopper in the tipple. The coal from each car is weighed and credited to the loader of that car. Each loader has a check number, which is attached to his car.

Tipple and Surface Plant

The tipple consists of a headframe only. Coal is dumped into a weighpan and then dropped into a feeder, which empties into a crusher where it is reduced to 4-inch maximum size. From the crusher it goes to railroad cars.

Major repairs to mining machines are made at a central shop serving two mines.

Mine employees, based on production of 530 tons per day

Class	Number of men	Hours worked per day	Total man-hours	
Cagers	2	(1 - 7 (1 - 7.5	14.5	
Drivers	16	7	112	
Trackmen	2	7	14	
Sulphur breaker	1	7	7	
Back brushers (night)	7	7	49	
Driller (night)	1	7	7	
Machine boss (night)	1	7	7	
5 machine crews (day)	15	7	105	
5 machine crews (night)	15	7	105	
Face boss	1	7	7	
Mine foreman	1	8	8	
Total day-wage employees underground	62		435.5	
Loaders (by ton)	145	7	1,015	
Total men underground	207		1,450.5	1,450.5

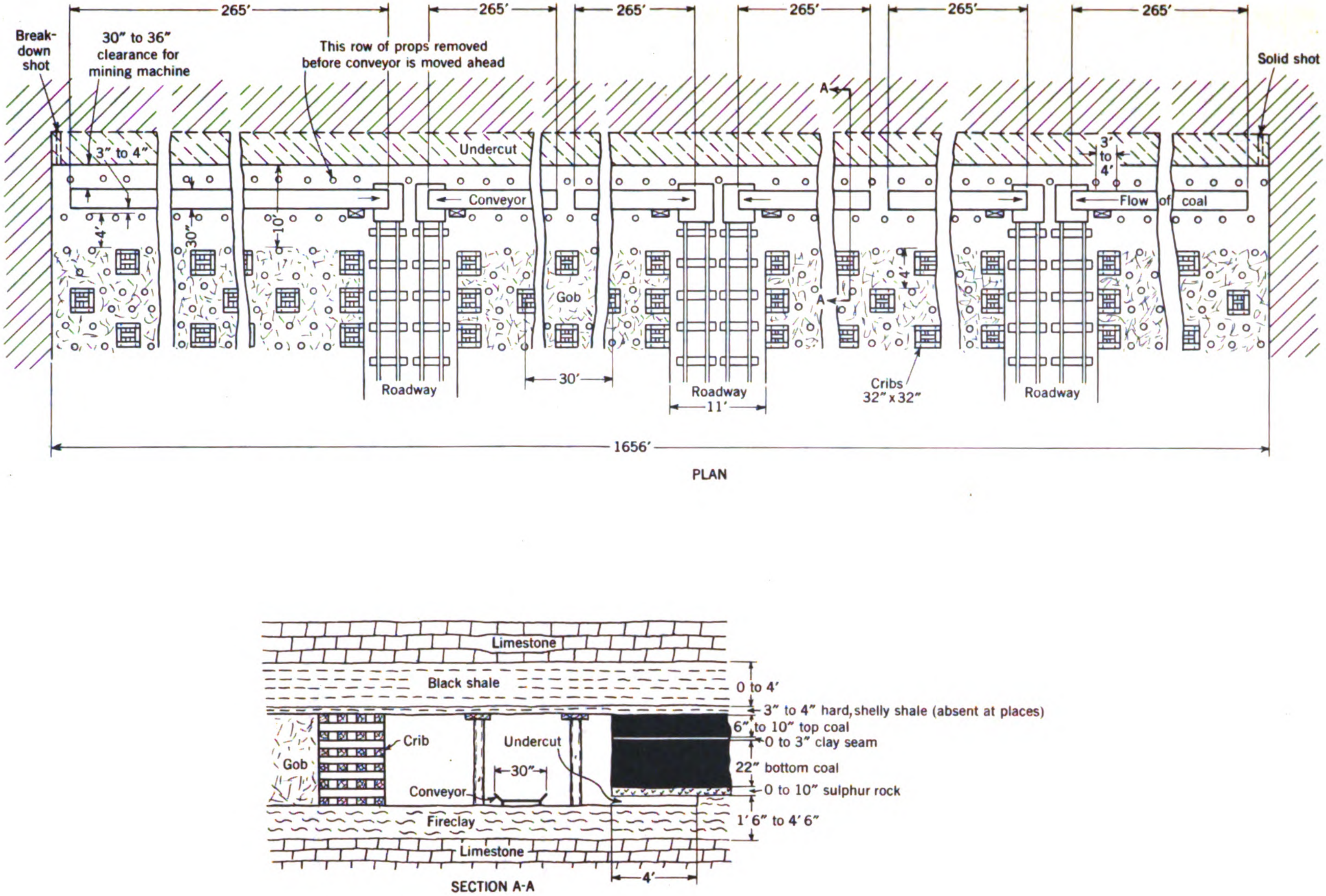

Figure 8.—Sketch of longwall face, mine No. 7, using conveyors.

Mine employees, based on production of 530 tons per day - Continued

Class	Number of men	Hours worked per day	Total man-hours	
Top employees				
Engineers	2	8	16	
Firemen	2	8	16	
Dirt-disposal engineer	1	7	7	
Car trimmer	1	7	7	
Weighman	1	7	7	
Blacksmith	1	7	7	
Machinist	1	7	7	
Carpenter (does repair work and extends electric line in mine)	1	7	7	
Total topmen	10		74	74
Total all employees	217			1,524.5

Summary

Class	Number of men	Total man-hours per day	Tons per man per day	Man-hours per ton per day
Loading	145	1,015	3.65	1.915
Entry brushing	10	72	53.00	.136
Coal cutting	32.5	227.5	16.30	.429
Haulage and hoisting	20	142.5	26.50	.269
Miscellaneous underground	5	36	106.00	.068
Miscellaneous top	4.5	31.5	117.77	.059
Total	217.0	1,524.5	2.44	2.876

This mine furnishes an example of advancing longwall mining, using a face track.

Mine No. 7

Location and General Description of District

This mine is in the northwest part of Ray County, Mo., and has railroad facilities.

The topography of the country adjacent to the mine is very rough. Due to this uneven topography, the depth of the overburden over the coal seam is very irregular. The coal seam lies comparatively level.

General Geology

The Lexington seam is mined in this operation. The thickness of the seam averages 28 to 32 inches. A section of the seam, with the overlying and underlying strata, is shown in figure 8, section A - A.

There is a clay parting in the seam up to 3 inches in thickness. The top coal above the parting ranges from 6 to 10 inches in thickness. Immediately over the top coal is a black shale, up to 4 feet in thickness. When this shale is less than 12 inches thick it gives considerable trouble, in that it does not come with the coal but hangs and falls later in large pieces. At some places there is a stratum of hard, shelly shale 3 to 4 inches thick between the coal and the black shale. Above the black shale is the limestone cap rock, which averages 11 feet in thickness.

Description of Mine

The hoisting shaft is 360 feet deep and has two compartments for hoisting. It is the upcast airway of the ventilating system. The air shaft, which is downcast, contains an air compartment and escapeway. The fan is a 3- by 5-foot-diameter high-speed fan driven by a 25-horsepower, a.c. motor.

The mine was developed for the use of conveyors on a longwall face. This system was in use continuously for 10 years until 1934, when the conveyors were removed and operations changed to a longwall system using individual roadways. Because of the varying thickness of the black shale, face-track longwall was considered impractical. The open space required for track and cars without timbering could not be obtained with the roof conditions existing here. The longwall system now in use will not be described. The conveyor system formerly employed is interesting and although discontinued merits description.

Various reasons were given for the change in system of mining, including obsolescence of the conveyors (they were heavy and of an old type) and, the decrease in demand for coal in the markets served by this mine, and necessity for a large investment in new equipment.

Longwall Operations with Conveyors

Refer to figure 8.

The working face was started by making a cut approximately 1,656 feet long from and parallel to the main entry which had been driven from the shaft. At the center of this face and at about 552 feet on each side of the center roadways were started by brushing the fireclay bottom to a depth of 24 inches and a width of 11 feet. The fireclay brushing came loose in large chunks, which were used to build the roadwalls to partly support the roof. Later, after maximum settling of the roof, usually about 40 to 60 feet back from the face, the black shale was drilled and shot down in the roadways to obtain height for the haulage animals. The ultimate height of the roadways averaged 4 feet.

Each roadway was double-tracked for a distance sufficient to hold 25 1-ton mine cars on each track, approximately 150 feet.

At the face and parallel to it were two conveyors for each roadway. These conveyors delivered the coal to the roadway and discharged it into cars, and a crossover from one track to the other permitted loading cars from both conveyors at the same time. These conveyors were 265 feet long, and there were six in all, two for each roadway. The conveyors were 30 inches wide and of the double-pan and double chain type. They were in one 11-foot head section, twenty five 10-foot sections, and one 5-foot tail section. The 11-foot section was at the roadhead and included the driving mechanism. Each conveyor was operated by a 15-horsepower, a.c. motor.

Cutting

Six longwall cutting machines equipped with 4-foot cutter bars were used. There was one machine to each conveyor. All cutting was done at night in the fireclay under the coal. Each machine cut approximately 276 feet in an 8-hour shift. Three men were used on each machine - a runner and two helpers. The helpers shoveled the machine cuttings into the gob and set props behind the machine between the conveyor and face. This row of timbers was approximately on 3-foot centers.

At one end of the wall where the cutting machine cut in, it was necessary to drill a hole in the coal, preliminary to shooting with black powder. This was called the breakdown shot. At the other end of the face where the machine cut out, another hole was drilled into the solid coal and also was shot with black powder. It is shown in the sketch (fig. 8) as the "solid shot." The fact that this longwall face was between solid coal on each side made it necessary to shoot down the coal on both ends of the cut to start the face coal to drop.

There were 11 loaders to each conveyor, and they loaded approximately 75 tons from 276 feet of face. After the coal was loaded, the props between the conveyor and face were knocked out, and the conveyor moved ahead to within 30 inches of the face - the distance necessary to clear the cutting machine. If roof was bad, it was necessary to set props ahead of the row to be knocked out and advance the conveyor in stages instead of at one move. After the conveyor was set in its new position, timber cribs 32 inches square and set on approximately 30-foot centers were built from props approximately 4 feet ahead of the gob wall. The rows were staggered. The cribs, machine cuttings, roof slate, and impurities thrown into the gob, together with the roadwalls, supported the roof and permitted gradual settling of the overburden. The slow movement broke the coal at the face, and the main weight was thrown back onto the gob.

Each conveyor had the following crew:

1 machine crew at night
1 driver)
1 chunker) to each roadhead or two conveyors
1 face boss)
11 loaders

Bottom brushing and building the roadwalls were done at night by six men for three pairs of conveyors. Three other men for three pairs of conveyors working at night brushed the roof of the entries. This was the back brushing. The shale was drilled and shot down. This rock was loaded into cars, taken to the shaft, hoisted, dropped into a rock car, and hauled up an incline and dumped on the rock pile or dirt dump.

The area worked out in this panel from 1931 to 1935 by this system was approximately 1,656 feet wide by 2,000 feet long; about 76 acres.

Haulage

The mine cars were hauled by a storage-battery locomotive from the double-track switch in each roadway in 25-car trips. Two of these locomotives operated on the day shift and one at night.

Spotting of cars from the double-track storage tracks in each roadway to the conveyor loading head was done with Shetland ponies working in teams, one team to each roadway. The track gage was 36 inches and capacity of the cars about 1 ton.

Hoisting

The cars were hoisted on self-dumping cages. Cars were cross-caged on the bottom.

The hoist was 150-horsepower, a.c., operated by remote control; the hoisting engineer was stationed in the tipple.

Tipple and Surface Plant

The coal was dumped from cars onto the shaker and prepared in the following sizes:

Inches	Grade	Percent
1 1/4	Screenings	10
1 1/4 by 3	Nut	10
3 by 10	Lump	40
10	Chunks	40

The tipple was arranged for loading on four railroad tracks.

Mine employees, based on production of 450 tons per day

Class	Number of men	Hours worked per day	Total man-hours per day	
Cagers	1	9	9	
Empty puller	1	8	8	
Load dropper	1	8	8	
Motormen (day)	2	8	16	
Motormen (night)	1	8	8	
Trip riders	2	8	16	
Drivers	3	8	24	
Trackmen	2	8	16	
Top brushers (night)	3	8	24	
Bottom brushers (night)	6	8	48	
Shot firer (night)	1	8	8	
6 machine crews (night)	18	8	144	
Loaders	66	8	528	
Conveyor operators	3	8	24	
Chunkers	3	8	24	
Maintenance men	3	8	24	
Night foremen	2	8	16	
Mine foreman	1	8	8	
Total men underground	119		953	953
Top employees				
Engineer (day)	1	9	9	
Engineer (night)	1	9	9	
Mechanics	2	8	16	
Dirt-disposal engineer	1	8	8	
Tipplemen	4	8	32	
Topmen	2	8	16	
Blacksmith	1	8	8	
Total topmen	12		98	98
Grand total	131			1,051

Summary

Class	Number of men	Total man-hours per day	Tons per man per day	Man-hours per ton per day
Loading	75	600	6.00	1.333
Entry brushing	10	80	45.00	.178
Coal cutting	20	160	22.50	.355
Haulage and hoisting	13	107	34.61	.238
Miscellaneous underground	5	40	90.00	.089
Miscellaneous top	8	64	56.25	.142
Total	131	1,051	3.43	2.335

All employees were on a day-wage basis.

This mine furnishes an example of longwall mining, using conveyors, in the Lexington seam.

EXCELSIOR FIELD, ARKANSAS

General Description of District

The Excelsior field is in the western part of Sebastian County approximately 20 miles south of Fort Smith.

The topography of the area is marked by high ridges and flat valleys.

The Midland Valley Railroad traverses the region and serves most of the mines in this field.

Geology

The Hartshorne coal seam, which is mined in the Excelsior field, outcrops along the south side of Backbone Ridge and dips south. At the outcrop the dip ranges from 2 to 3°, decreasing as it extends south. It lies above the Hartshorne sandstone in the Greenwood syncline and is near the base of the Spadra formation.[4]

The coal seam at the mine visited had an average thickness of 30 inches. Above the seam was a draw slate averaging 2 inches in thickness. The roof over the draw slate was a hard, black slate. Under the coal was a few inches of hard sandy shale and beneath this the Hartshorne sandstone.

A proximate analysis of the coal is as follows:[5]

Moisture, as received...	percent	3.64
Volatile matter.........	do.	16.57
Fixed carbon............	do.	76.00
Ash.....................	do.	3.79
Sulphur.................	do.	.83
B.t.u.		14,525

Mine No. 8

This mine is near Hackett, Ark., and has railroad connections. The daily production is approximately 325 tons, which is sold commercially in the markets of the Middle West.

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[4] Collier, A. J., The Arkansas Coal Field: U.S. Geol. Survey Bull. 326, 1907, p. 12.

[5] Collier, A. J., Work cited, p. 97. Arkansas State Inspector of Mines, **Annual Report:** 1924, p. 9.

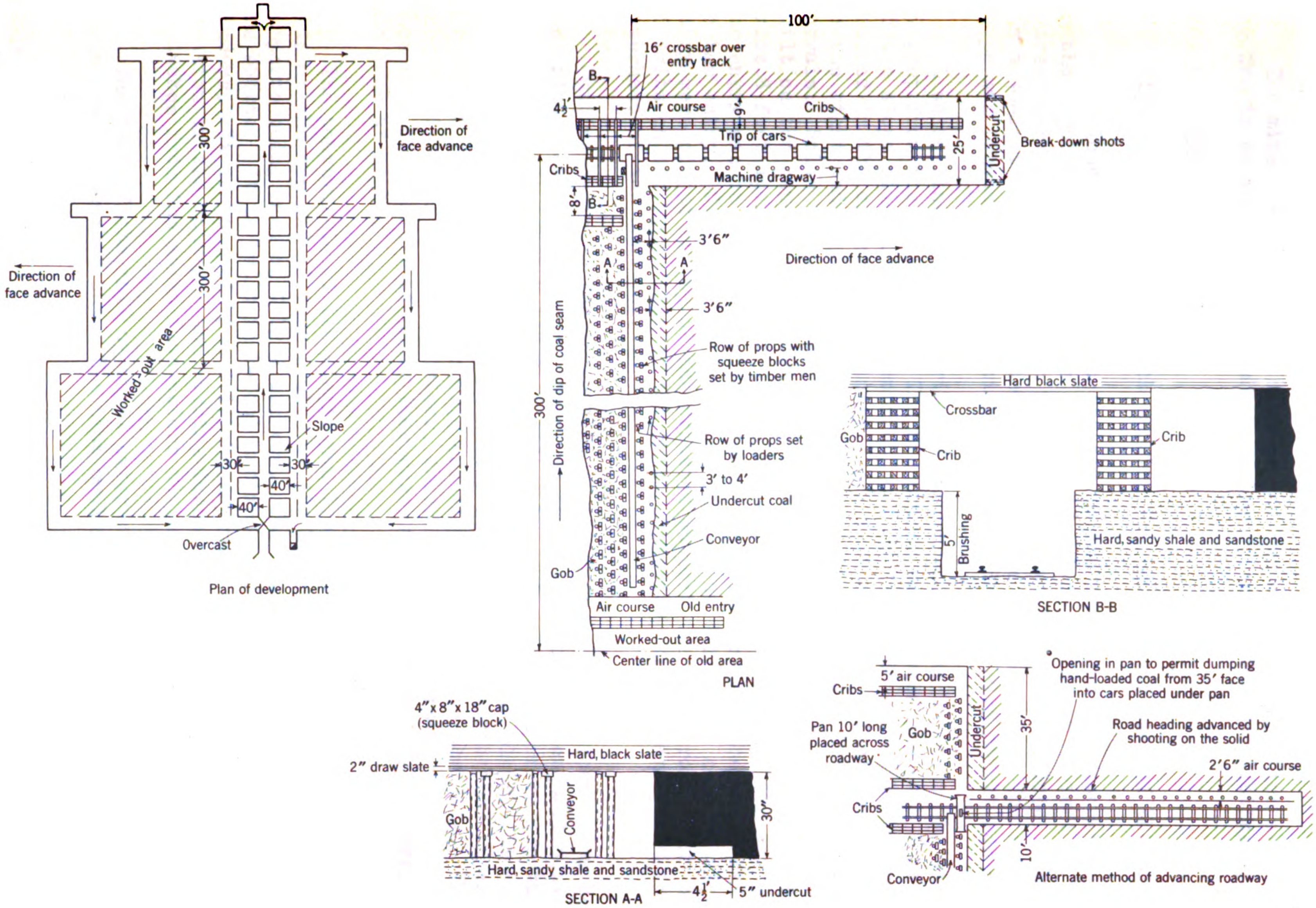
Direction of face advance
300′
300′
Direction of face advance
Worked-out area
Slope
30′
30′
40′
40′
Overcast
Plan of development
100′
16′ crossbar over entry track
B
4½′
Air course
6′
Cribs
Trip of cars
25′
Undercut
Break-down shots
Cribs
Machine dragway
8′
B
3′6″
A
A
Direction of face advance
3′6″
Row of props with squeeze blocks set by timber men
300′
Direction of dip of coal seam
Row of props set by loaders
3′ to 4′
Undercut coal
Conveyor
Gob
Air course
Old entry
Worked-out area
Center line of old area
PLAN
Hard black slate
Crossbar
Gob
Crib
Crib
Brushing
5′
Hard, sandy shale and sandstone
SECTION B-B
4″ x 8″ x 18″ cap (squeeze block)
2″ draw slate
Hard, black slate
Gob
Conveyor
30″
Hard, sandy shale and sandstone
4½′
5″ undercut
SECTION A-A
5′ air course
Cribs
Pan 10′ long placed across roadway
Gob
Undercut
35′
Opening in pan to permit dumping hand-loaded coal from 35′ face into cars placed under pan
Road heading advanced by shooting on the solid
2′6″ air course
Cribs
10′
Conveyor
Alternate method of advancing roadway

Figure 9.–Plan of working face of a longwall mine – Hackett (Ark.) area.

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The mine was opened with a slope and two air courses, which are the manways. The fan is at the air course which is the return in the ventilating system.

System of Mining

Figure 9 includes a sketch showing the development plan of the mine.

The slope was driven down the dip in the coal seam. Crosscuts were made to the right and left from the slope every 40 feet, and at 40 feet in the air courses were turned and driven up the pitch parallel to the slope. Thus there was a 40-foot coal pillar protecting each side of the slope. The bottom of the slope was brushed 7 1/2 feet wide and 5 feet deep to give height for haulage.

A solid line of timber cribs 34 inches square was built in the air courses 15 feet from the solid face. The air course was between the crib line and face of the slope pillar. Branch entries, cut 25 feet wide and with the bottom brushed in the center of the entry 7 1/2 feet wide and 5 feet deep, were turned to the right and to the left at right angles to the slope and at 300-foot intervals. Solid timber cribs 34 inches square and made from sawed timbers were built on the bench on the down side of the brushed roadway, and a double row of cribs 8 feet apart was built on the upper side of the entry. The air course of the entry was on the lower side between the crib line and the solid face parallel to the entry. Crossbars 16 feet long and set on 4 1/2-foot centers along the entry were placed on top of the cribs to support the entry roof. The double row of cribs on the upper side of the entry supported the roof and protected the powerhead of the conveyor.

Cutting began at the lower side of the face in the 15-foot space between the cribs erected in the air course at the solid face. A longwall mining machine equipped with a 4 1/2-foot cutter bar cut a 5-inch kerf in the bottom of the coal seam along the 300-foot face that paralleled the slope. It also cut around the face of the entry, advancing it to maintain a distance of approximately 100 feet from the discharge end of the conveyor to the face. The machine crew consisted of a runner, helper, shoveler, and timberman. The 300 feet of face plus the 25 feet of entry face were cut in approximately 8 hours. Cutting was done at night.

The conveyor is of the single-pan type with single chain. It is 24 inches wide at the top and 18 inches wide at the bottom and is light in weight, the supports being made of 2 by 4 timbers. The chain returns under the pan along the bottom. It is built in 6-foot sections and is easily manipulated around timbers. It is powered by a 7 1/2-horsepower, a.c. motor. Figure 9 shows the location of the conveyor and working faces. The conveyor is placed approximately 42 inches from the solid face before it is cut.

The face of the wall or panel extends from the lower entry to the one above, which has been worked out. The crew employed on a 300-foot face is usually as follows:

10	loaders
1	face boss
1	chunker
2	entrymen
2	brushers
3	machinemen
1	timberman
1	engineer
21	

The same crew would be used on a 240-foot face, except that the loaders would be reduced to eight men. Approximately 125 tons of coal is extracted from a 300-foot face and 100 tons from a 240-foot face. At present, three faces or panels are being worked.

The loaders remove the cut coal and place it on the conveyor, set one row of props approximately 42 inches from the solid face on 3- to 4-foot centers; and move the conveyor ahead one cut (4 1/2 feet); this cycle of operations usually takes 7 hours. It requires approximately 45 minutes to move the conveyor ahead and prepare it for operation.

The engineer and chunker move the powerhead of the conveyor ahead and extend the double row of cribs along the upper side of the entry.

The two entrymen load the coal from the face of the entry, erect cribs on the lower side, and place a 16-foot crossbar over the entry just ahead of the conveyor powerhead. One end of the crossbar is supported by a crib on the lower side of the entry, and the other end is supported on heavy props. Later, as the conveyor is moved ahead, the end of the crossbar is caught by cribs. The entrymen also drill two breakdown shots in the corners of the entry face and shoot down this coal. All of the work is usually done in a 7-hour shift.

Another method of advancing the roadway ahead of the working face is being tried. A steel pan 10 feet long, constructed of plate reinforced with 4- by 4-inch angles, is placed across the bottom-brushed roadway from bench to bench. The bottom of the pan is solid, except for a 4-foot opening in the center. When the mining machine reaches the side of the roadway adjacent to the longwall face, it is pulled across this pan or "spanner" to the other side of the roadway. From here it cuts an additional 35 feet of face on the down side of the roadway. If the machine is at the down side of the roadway, it would first cut the 35-foot face, then cross the spanner and start work in the 300-foot face.

In the other method, the mining machine on reaching the roadway would be dragged along the bench on the upper side of the roadway 100 to 125 feet to the entry face. The spanner eliminates the "deadheading" of the mining machine from longwall face to roadway face, which consumed considerable time and labor.

The spanner pan not only serves as a bridge for carrying the mining machine from one side of the roadway to the other but also aids in loading. The two loaders who work along the 35-foot face pass the undercut coal onto the pan and through the opening into cars placed in the roadway under the pan.

The pan remains across the roadway at all times and is moved ahead as the longwall face is advanced.

The face of the roadway is kept 100 to 125 feet ahead of the longwall face and is brushed in the bottom, as in the other method. The roadway is advanced by hand and shot on the solid to a width of 10 feet in the coal. A temporary air course is carried 30 inches wide along the down side of the roadway. A permanent air course is made by building a solid row of cribs 5 feet from the solid coal on the down side of the 35-foot face.

Figure 9 includes a sketch showing the method of roadway advance.

The two brushers work at night. They drill and shoot the bottom brushing in the entry and load brushing into cars. These are hoisted and dumped on top.

The timberman, who works with the machine crew at night, sets a second row of props in front of the conveyor. The props have a 4-by 8- by 18-inch cap piece called a "squeeze block", which is wedged against the roof.

The slope and new branch entries are developed by a machine crew of two men and one fireboss.

Roof Support and Control

Figure 9 also shows the location and method of timbering used in this mine. The squeeze block used on the timbers adjacent to the conveyor acts as the term implies. Instead of the weight of the overburden pressing directly on the prop and breaking it, the squeeze block is gradually mashed, and most of the weight is directed into the gob and part of it to the face. The weight acting on the face breaks the coal down after it has been undercut.

As the worked-out area increases, the roof gradually subsides from the weight of the overlying strata and slopes from the face toward the gob in the worked-out area. Finally the squeeze blocks are mashed completely, and the angle of the roof is such that the props are kicked out and the roof rests on the gob, which consists of draw slate and other debris that have been thrown into it. The movement has been gradual since the squeeze blocks were introduced, and breaks that occur in the roof do little damage at the face. Prior to the use of squeeze blocks falls of roof were frequent, and a great amount of trouble resulted. The introduction of the squeeze blocks or caps decreased the unsupported area between props, and gradual crushing of this block prevented sudden application of the weight on the prop.

The depth of the overburden varies and at the face of the slope was approximately 200 feet. Some of the strata in this overburden contain water, which drains down the breaks into the mine, and through the gob to the entries, where it is gathered in sumps and discharged to the surface by pumps.

Haulage

The grade in the right branch entries was down toward the face and in the entries at the left up toward the face. An electric hoist let the trip of cars down to the loading end of the conveyor in the right entries, and on the left entries pulled the trip of cars to the loading station.

There was a parting or storage track for both loads and empties in each branch entry off the slope; empties were delivered to the loading station and loads returned to the partings by the electric hoists.

A trip consisted of 10 cars, each car having a capacity of approximately 2,500 pounds.

Hoisting

Loaded trips were hoisted up the slope to the tipple. Brushing rock was hoisted at night and dumped onto a rock chute, whence it was hoisted by another electric hoist over an incline for disposal on the rock dump.

Tipple and Surface Plant

The tipple is constructed of wood and has storage tracks for loads and empties. The coal is dumped onto shaking screens and prepared. The sizes vary with the demand and usually are as follows:

Inches	Grade
+10	Fancy lump
10 by 2 1/2	Grate
-2 1/2	Nut

Mine employees, based on production of 325 tons per day

Class	Number of men	Hours worked per day	Total man-hours per day	
Fireboss....................	1	7	7	
Rope rider..................	1	7	7	
Switcher....................	1	7	7	
Pumper......................	1	7	7	
Electrician.................	1	7	7	
Loaders.....................	24	7	168	
Face bosses.................	3	8	24	
Chunkers....................	3	7	21	
Entrymen....................	6	7	42	
Brushers....................	6	7	42	
3 machine crews.............	9	8	72	
Timbermen...................	3	8	24	
Engineers...................	3	7	21	
Mine superintendent.........	1	8	8	
Mine development............	3	7	21	
Total men underground.......	66		478	478
Top employees				
Engineers...................	2	8	16	
Car trimmers................	2	7	14	
Coupler.....................	1	7	7	
Weighman....................	1	7	7	
Blacksmith..................	1	7	7	
Total topmen................	7		51	51
Total all employees.........	73			529

Summary

Class	Number of men	Total man-hours per day	Tons per man per day	Man-hours per ton per day
Loading 1/..................	33	234	9.85	0.720
Entry brushing..............	6	42	54.16	.129
Coal cutting................	9	72	36.11	.221
Haulage and hoisting........	7	51	46.42	.157
Miscellaneous underground, including development...........	13	95	25.00	.292
Miscellaneous top...........	5	35	65.00	.108
Total.......................	73	529	4.45	1.627

1/ 3 entrymen included in loading and 3 entrymen in miscellaneous underground.

This mine is an example of longwall mining, using conveyors, in a 30-inch seam of coal.

PARIS FIELD, ARKANSAS

General Description of District

The Paris coal field is in Logan County approximately 40 miles east of Fort Smith and adjacent to Paris, the county seat.

The Missouri Pacific and Fort Smith, Subiaco & Pacific Railroads serve this district. Practically all of the tonnage from the mine is shipped by rail to markets in the Middle West and Northwest.

The topography of the area is rolling to rough. Two large "buttes", locally called Short Mountain and Little Short Mountain, overlie the coal basin.

A sketch map of this coal field is shown in figure 10. The Paris Basin or field is approximately 3 miles wide north and south by approximately 6 miles long east and west.

Geology

The coal seam lies in an elliptical basin. The seam dips from the outcrop around the basin toward the center. The dip varies, averaging 8° 30' at the crop line and decreasing as the center of the basin is approached. The overlying strata are sandy shales, with thin beds of shaly sandstone.

The thickness of the seam ranges from 18 to 32 inches. The coal appears to be thinnest along the west outcrop and thickest at places on the north outcrop. Usually there is a band of bony 4 to 7 inches thick on top of the coal. This bony adheres to the coal. In some mines there is a 1/2- to 1-inch clay seam, locally called "muck", which separates the bone and coal from the hard, sandy shale roof. At other places this muck seam does not exist, and the bony and coal adhere to the roof. Below the coal seam is a hard, sandy shale. At places there is a seam of fireclay a few inches thick between the coal and this hard shale bottom.

Collier, in Geological Survey Bulletin 326, page 81, states, "Chemically it is semibituminous and somewhat higher in hydrocarbon than the average Hartshorne coals in the same region." Locally and in the Kansas City markets it is classed as a semianthracite. It is a high-grade, smokeless coal.

A proximate analysis is as follows:[6]

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[6] Collier, A. J., work cited, p. 98.

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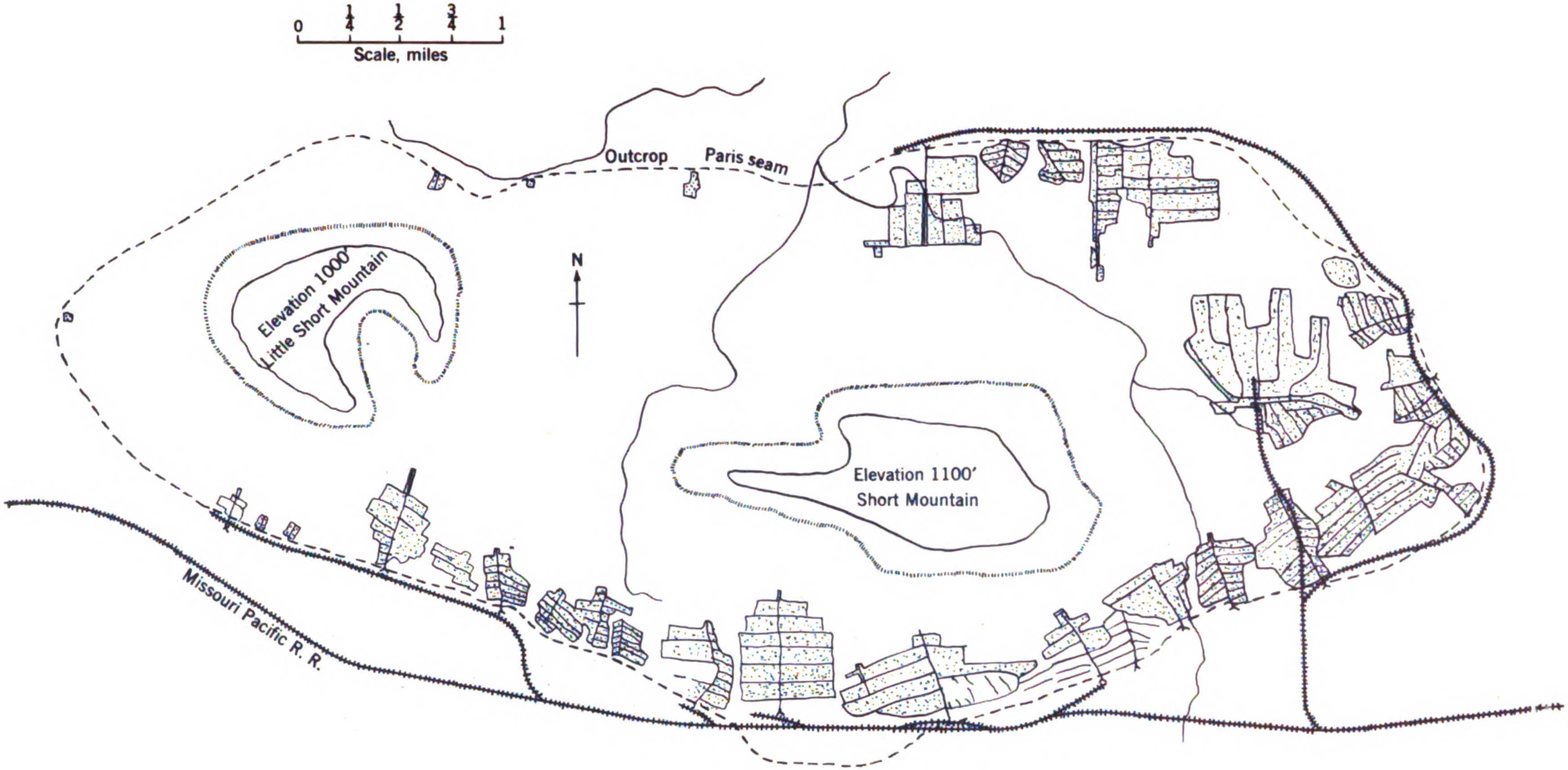

Figure 10.– Map of Paris coal field, Logan County. Ark.

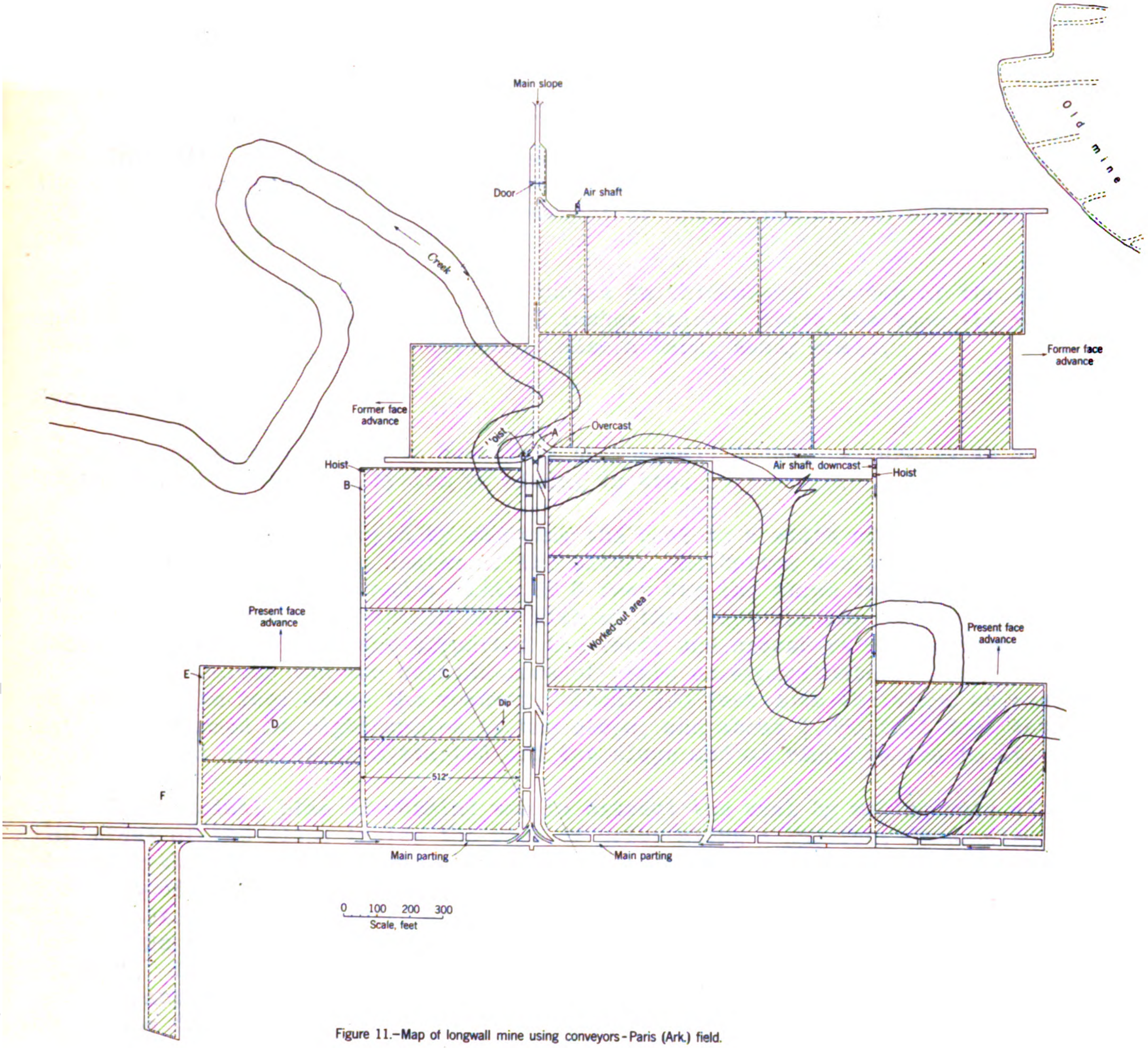

Figure 11.–Map of longwall mine using conveyors-Paris (Ark.) field.

As received, moisture....percent		2.77
Volatile matter.........	do.	14.69
Fixed carbon............	do.	73.47
Ash,....................	do.	9.07
Sulphur.................	do.	2.79
B.t.u.		13,774

Mine No. 9

This mine was opened with a slope driven from the outcrop of the coal down the dip of the seam. The grade for the first 450 feet was approximately 8°-30' but gradually diminished to about 3 percent at the bottom of the slope, which is down approximately 2,300 feet.

The coal seam averaged 20 to 22 inches in thickness. On top of the seam, and adhering to it, is a "bone" 4 to 7 inches thick. Above the bone the roof is a hard, sandy shale. The bottom is also a hard, sandy shale.

System of Mining

This mine is using chain conveyors on longwall faces. Figure 11 is a plan of the mine, showing the system of mining in use.

The slope was developed by removing the coal to a width of 50 feet for about 1,100 feet. In the center of the slope, the bottom was brushed to a depth of 4 1/2 to 5 feet and a width of 8 feet for the slope track. A double line of timber cribs was set on each side of the slope roadway on the bench above the track. The cribs supported the roof, and crossbars were placed over the roadway across the two outside rows of cribs on approximately 3-foot centers to support the roof above the roadway. About 300 feet down the slope an east entry was turned at right angles to the slope, and about 1,050 feet down both east and west entries were started off the slope and at right angles to it.

The original plan of working was to extract the coal by making cuts along the sides of the slope inside the rows of cribs along a 350-foot face, discharging the loaded coal from conveyors into cars set in the 1st east entry. This procedure was followed along the 1st east to its end. Operations were then started at the 2d east, and extraction paralleled the slope between the 1st and 2d east. The conveyors discharged the loaded coal into cars set on the 2d east. This system was continued until the coal between the 1st and 2d east was extracted. The same method of operation was followed on the west side of the slope from the 1st west.

The direction of the slope, descending, was due south, and the direction of the slips in the overlying strata above the coal seam was approximately S. 10° E., nearly parallel to the slope and the faces of the 1st and 2d east and 1st west walls. The natural slips in the roof were practically parallel to the faces of the walls making it difficult to hold the roof. It was therefore decided to carry future working faces approximately east and west as nearly at right angles as possible to these natural slips or planes in the strata overhead.

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Beginning at the 2d east, the slope was extended down the dip approximately 1,200 feet. The slope was cut to a width of about 12 feet and the bottom brushed to a depth sufficient to give 6 feet clearance above top of rail. Air courses were driven on each side of the slope. The distance between the center lines of the slope and air courses was approximately 40 feet. East and west entries were turned at the face of the slope and at right angles to it. The system of mining is the same on both the east and west sides of the mine, and the operation on only one side will be described.

A coal pillar was left between the 2d west entry and its air course. Center line between the entry and air course was about 40 feet. The 2d west entry was brushed in the bottom deep enough to give clearance of 6 feet above the top of the rail. The air course of the slope was brushed in the bottom for a distance sufficient to permit storage of 12 empty cars inside the air course of the 2d west entry. A 40-horsepower electric hoist was placed at the head of the slope air course at the 1st west entry. (Refer to fig. 11, hoist placed at A.)

Beginning at the slope air course, holes were drilled on 32-foot centers 3 1/2 feet deep in the coal along the side of the 2d west air course for a distance of 512 feet. After the face had been cut, these holes were loaded with 4 to 6 inches of black powder and shot. These are called the "break-in shots."

A longwall mining machine equipped with a 4 1/2-foot cutter bar undercuts the 512 feet of face. The cutting is done in the bottom under the coal. Three men, a runner and two helpers, operate the machine at night. The undercut or kerf averages 5 inches. Two men on day-shift sump in the cutter bar at the beginning of the face. In this way the machine is ready to cut across the face when the machinemen report for work at night. The 512 feet of face is usually cut in 7 hours.

The conveyor, which is 500 feet long and of the double-pan and single-chain type, is set approximately 4 1/2 feet from the face. The conveyor is driven by a 15-horsepower, a.c. motor.

For each conveyor the following crew, exclusive of the machinemen is employed:

17	loaders
2	chunkers
1	face boss
1	engineer

The loaders clean the bony off the top of the coal with picks, and then load the fallen coal into the conveyor. After the coal is loaded, they set a row of props approximately 4 1/2 feet from the solid face of coal; drill the "break-in shot" holes every 32 feet along the face; and knock out the row of props next to the conveyor and move it ahead 4 1/2 feet. If the roof is bad

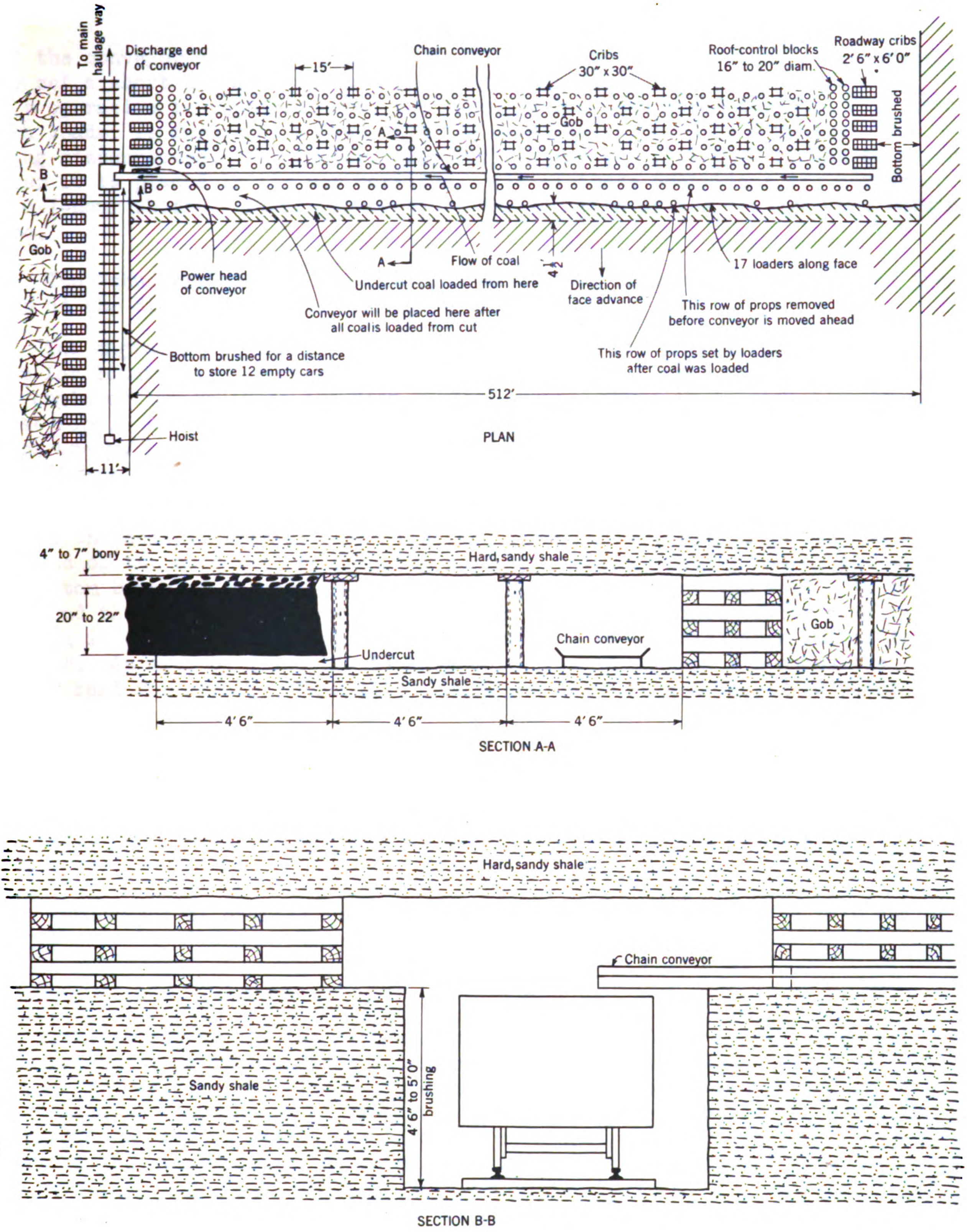
To main haulage way
Discharge end of conveyor
15′
Chain conveyor
Cribs 30″ x 30″
Roof-control blocks 16″ to 20″ diam.
Roadway cribs 2′ 6″ x 6′ 0″
Gob
A
B
Bottom brushed
Power head of conveyor
Undercut coal loaded from here
Flow of coal
4′
Direction of face advance
17 loaders along face
Conveyor will be placed here after all coal is loaded from cut
This row of props removed before conveyor is moved ahead
This row of props set by loaders after coal was loaded
Bottom brushed for a distance to store 12 empty cars
512′
Hoist
PLAN
11′
4″ to 7″ bony
Hard, sandy shale
20″ to 22″
Undercut
Chain conveyor
Gob
Sandy shale
4′ 6″
4′ 6″
4′ 6″
SECTION A-A
Hard, sandy shale
Chain conveyor
Sandy shale
4′ 6″ to 5′ 0″ brushing
SECTION B-B

Figure 12.—Sketch of longwall face using conveyors-Paris (Ark.) area.

and the conveyor cannot be shifted the full distance at one move, other props are set a short distance ahead before the first line of props is taken out. This operation is repeated until the conveyor has been moved the full distance. Each loader is furnished a jack, and the conveyor is moved as a unit without being disconnected. The loaders also build a row of cribs back of the conveyor after it is placed in its new position. All of these operations are performed in a 7-hour shift. Figure 12 sketches the location of the conveyor and working face.

Two "chunkers" operate the conveyor and attend to spotting and loading the cars at the discharge end of the conveyor.

The engineer operates the hoist, which lowers the trip of cars and places them for loading as directed by the chunkers. After a trip of cars is loaded, the engineer lowers it to the main haulage entry, where it is picked up by the hoist rope. The hoist is located at the parting or storage tracks. Empty trips are pulled back to the loading point at the face. The hoist is shown at A in figure 11.

As the coal is extracted and the face advanced, the bottom is brushed at each end of the conveyor, to form the roadway. At the loading end of the wall the bottom brushing is kept 12-car lengths or more ahead of the wall. At the other end the brushing is kept about one cut back of the face of the wall. The brushing is done at night, and the track extended at the discharge end of the conveyor. As area C, (fig. 11) is advanced, brushed roadway B becomes the loading road for area D. When this occurs the hoist at A is moved to point B.

Usually after the face of an area has been advanced several hundred feet, a hoist would be set, as at E, and another face started along area F.

One face is working on the east side of the mine, and two faces on the west side. An average of 120 tons is obtained from each cut along a 512-foot face.

Development of entries and slope is ordinarily done during the idle season using shortwall mining machines for cutting.

Roof Support and Control

Refer to figure 12. At each end of the 512-foot face, 2 1/2- by 6-foot cribs are built on the bench at each roadway. Adjacent to these cribs is placed a set of four oak blocks 16 to 20 inches in diameter and 28 inches long. Sometimes a greater number of blocks is used, since they control the settling action of the roof as well as protect the powerhead of the conveyor. The weight of the overburden is directed to the gob in the worked-out area.

Between the two large cribs and corner blocks at each end of the face, small cribs 30 inches square are set back of the conveyor on approximately 15-foot centers. Props are set between these small cribs on about 3- to 4-foot centers. The cribs and props are staggered as the position of the conveyor

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is advanced. Approximately 600 props are used in the cribs and timbering for each cut of coal. Machine cuttings, bony coal, and other impurities and rock that may fall from the roof are thrown into the gob and help support the roof as it subsides.

The first break in the roof over the area of coal being mined usually occurs after the face has advanced 50 to 60 feet. After the first break, the roof ordinarily breaks every 4 1/2 feet or, one cut, of advance of the face. These breaks sometimes show on the surface but soon seal themselves, due to the thick shale stratum in the overburden. There are several water strata in this overburden; the water runs down the breaks into the gob and drains from there to the entries, where it is gathered in sumps and relayed to the surface by pumps, powered with a.c. motors. The pumps deliver about 700 gallons per minute.

Haulage

The cars have a capacity of approximately 2 1/2 tons. There are usually 12 cars to a trip, which is handled as a unit. The trips are lowered down the slope to the main parting or storage track on the west entry at the face of the slope. The grade in the west entry is toward the face, and the trips of empties run to the parting by gravity. An electric hoist at the parting lowers the empties to the loading roadways on the west side of the mine and pulls the loads back to the parting. Another electric hoist is situated at the face of the east entry and handles the trips from that side of the mine back and forth between the loading roadway and the parting. From the parting the trips are pulled up the slope by the main hoist to the tipple.

Props and timbers are let down to the parting in cars and are delivered to the faces when needed.

Loads and empties are gathered entirely by the various electric hoists.

Hoisting

A 350-horsepower, a.c. electric hoist is situated in the tipple and is the main hoisting unit. The 12-car trips are passed through a rotary dump and emptied without uncoupling. The coal is discharged onto shaking screens for sizing. The hoisting engineer operates both the hoist and the rotary dump by remote control.

Ventilation

The air passes down the air shaft, situated approximately 1,000 feet east of the main slope and just south of the 2d east, and splits at the bottom of the shaft. One current passes south to the face of the 3d east wall, thence across the face and south to the 3d east, thence west along this entry to the slope; it returns up the slope to the air course, to the main air shaft, situated a little south and east of the slope mouth, then up the air shaft to the fan.

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Another current passes west along the 2d east entry through the overcast over the main slope, thence along the faces of the walls off the 2d west entry, south to this entry, and east along the 2d west to the slope, returning up the slope to the air course to the main air shaft and to the fan. There is a door on the slope just outside the air course to the main air shaft.

Tipple and Surface Plant

The tipple is equipped with shaking screens, which prepare the following sizes according to the demand:

Inches	Grade	Percent
8 by 14	Lump	-
8 by 10	do.	-
6 by 10	do.	-
8 by 2 1/2	Furnace	-
6 by 2 1/2	do.	-
1 1/4 by 2 1/2	Nut	4
1 1/4 by 1/2	Chestnut	6
-1/2	Slack	8

Machines and other mining equipment are repaired in a well-equipped shop.

Mine employees, based on production of 360 tons per day

Class	Number of men	Hours worked per day	Total man-hours	
Fireboss (gas man)	1	7	7	
Machine maintenance men (sumpers)	2	7	14	
Timbermen	2	7	14	
Parting hoisting-engineer	1	7	7	
Parting trip-rider	1	7	7	
Slope trip-rider	1	7	7	
Trapper	1	7	7	
Brushers	3	7	21	
Hoisting engineer for conveyors	3	7	21	
Chunkers	6	7	42	
3 machine crews	9	7	63	
Loaders	51	7	357	
Face bosses	3	7	21	
Mine foreman	1	8	8	
Total men underground	85		596	596
Top employees				
Hoisting engineer and dumper	1	8	8	
Cleaning tables	6	7	42	
Slate pickers	3	7	21	
Topmen	1	7	7	
Tipple operator	1	7	7	
Blacksmiths	2	7	14	
Car repairer	1	7	7	
Timber loader	1	7	7	
Total topmen	16		113	113
Total all employees	101			709

Summary

Class	Number of men	Total man-hours per day	Tons per man per day	Man-hours per ton per day
Loading.....................	57	399	6.31	1.108
Brushing....................	3	21	120.00	.058
Coal cutting................	11	77	32.72	.214
Haulage and hoisting........	8	57	45.00	.158
Miscellaneous underground...	7	50	51.43	.139
Miscellaneous top...........	15	105	24.00	.292
Total.................	101	709	3.56	1.969

This mine is an example of longwall mining in a thin seam of coal, using conveyors.

Mine No. 10

Mine No. 10 in the Paris Basin was opened by driving a slope from the surface through the overburden to the coal seam. This is a "rock" slope driven approximately 500 feet on an 18° pitch. The slope was continued in the coal toward the property line. From the foot of the rock slope section the dip of the seam is slight, as it follows approximately the axis of the basin. Figure 13 is a sketch showing the development of the mine.

The average thickness of the seam is 18 inches. Above the coal there is a hard slate of varying thickness, averaging 2 inches. Between the hard slate and the shale roof is a "muck" seam, which separates the coal and bony from the roof. When the coal is undercut the coal and hard slate separate from the roof, due to the muck parting. The characteristic of the seam - parting from the roof without shooting or wedging after the coal is undercut - brought about development of a system of longwall mining using "scows." Only this phase of the mining operation will be discussed.

System of Mining

The slope or main entry was brushed in the bottom. The height from top of rail to cross timber was approximately 6 1/2 feet. Longwall mining machines equipped with 4-foot cutter bars were started on each side of this main entry and cut a face approximately 420 feet long.

A bar extending into the cut was attached to the rear of the mining machine. Fastened to this bar was a 5/8-inch, 6- by 19-   plow-steel cable. As the machine progressed along the face this bar drew the cable along the rear of the cut in the kerf. There was a sheave at each end of the cut. One end of the cable was attached to a steel plate, called a "scow", 1/4 inch by 4 1/2 feet by 16 or 20 feet long. The cable passed around the sheave to one drum of a double-drum electric hoist. Another cable from the second drum of the hoist was run around a tightening sheave attached to a chain and jack, then around the second sheave at the face, and was attached to the other end of the scow. The hoist was driven by a 15-horsepower a.c. motor and the drums were 14 inches in diameter.

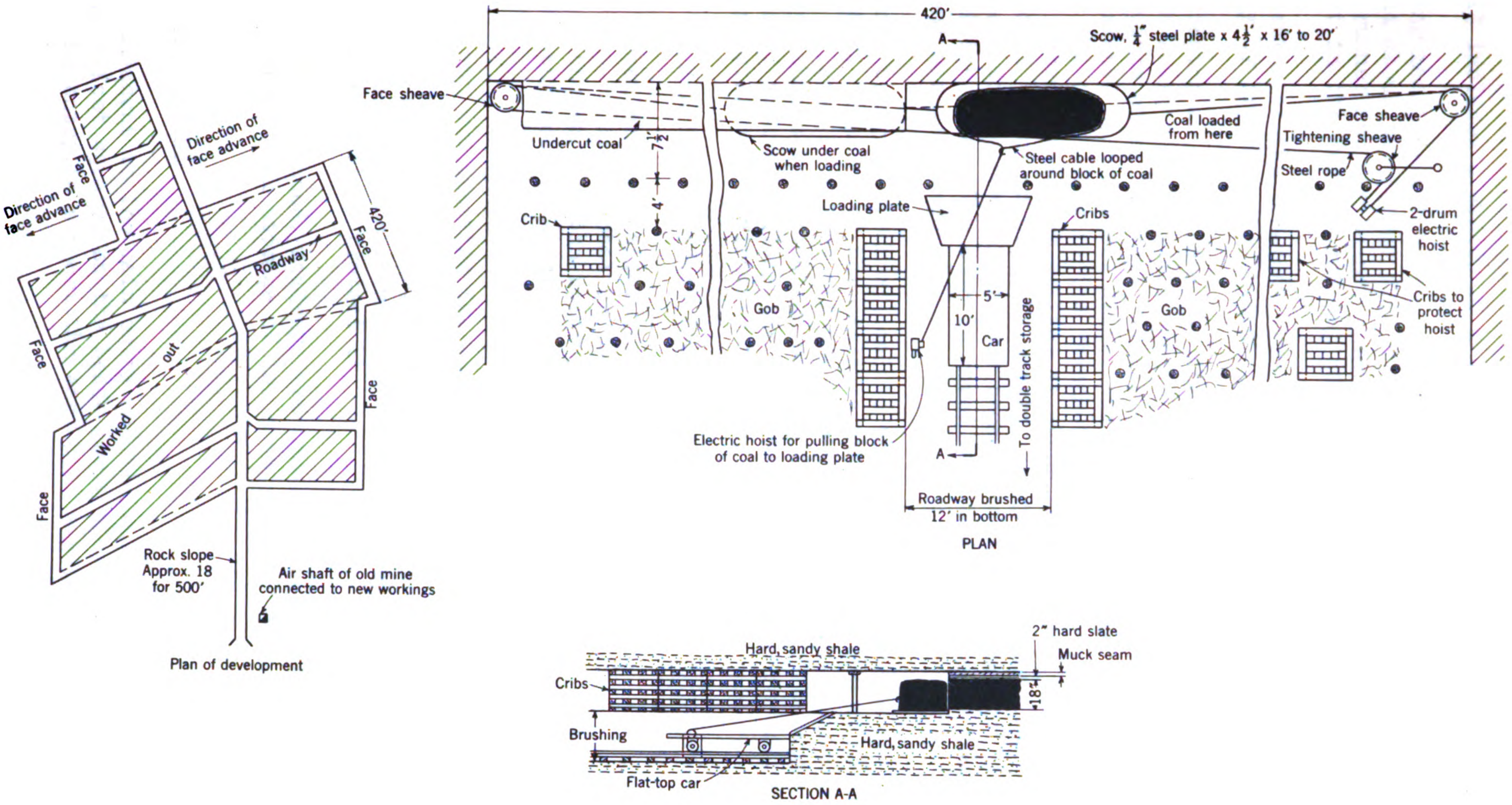

Figure 13.—Sketch of longwall face using a scow—mine No. 10.

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Figure 13 includes a sketch of a working face, using a scow.

The mining machines cut in the sandy shale bottom. The bottom is exceedingly hard and about two 7-hour shifts are needed to cut 420 feet of face. Three men, a runner and two helpers, operate the machine, which is run at night. Sprags are set in the kerf as cutting advances.

In the center of the 420-foot face a roadway was started at right angles to the main entry by brushing the bottom. A double track was laid in this roadway.

Loading begins at the roadway in the center of the cut. Sometimes a steel plate on which sharp spikes extend upward is placed in the kerf. As the coal falls, these picks enter the coal. A cable attached to an electric hoist in the roadway is fastened to the steel plate, and the hoist pulls the first chunk of coal out from the cut. This is the "break-in." The scow is now put in operation and is loaded automatically by pulling it under the cut coal. The load consists of blocks of coal 4 feet in width by varying lengths up to the length of the scow. The scow is held to the rear of the cut because of the position of the sheaves at each end of the face. The scow is moved back and forth under the coal until all of the coal has been removed.

As the scow brings a block of coal to the roadhead, a cable is placed around the block. The end of the cable is attached to a hoist in the roadway and the block of coal is pulled off the scow to a loading plate or chute. From there the large chunks are placed on cars 10 feet long by 5 feet wide, with a flat bed. Should rock fall along the face, it is also taken out on the scow. A 420-foot face yields approximately 80 tons.

The crew of men in a 420-foot face is as follows:

8 men who look after the loading of the scow, either coal or rock
2 chunkers at the roadway
1 engineer on hoist at roadway for pulling large blocks of coal off scow onto loading plate or chute
1 man who operates the scow hoist

After all the coal is loaded, these men set a row of props 3 feet back from the solid face, move the scow hoist ahead, and set cribs along the roadway and around the scow hoist to protect it.

As the face is advanced, roadways are usually brushed in the bottom 12 feet wide for double-track storage of loads and empties back of the loading plate.

Roof Support and Control

The roof adjacent to the main entry and roadways is supported by timber cribs, usually 4 feet square, on the bench above the brushing. Cross timbers extend across the entry to support the roof over the entries and rest on the cribs.

If the face is advancing up the dip, the direction of the weight will be toward the gob and toward the face if the face is advancing down the dip. The direction of pressure is usually toward the dip. The unsupported distance from prop line to solid face is usually about 7 1/2 feet.

The first break in the roof of a new face usually occurs 50 to 60 feet from the main entry and sometimes causes heavy rock falls back from the face, so that the roof is difficult to support, and heavy timbering along the face is then required. After the first break there usually is a break every 4 feet, and the weight is supported by props and cribs along the face. Considerable amounts of water enter the mine through these breaks. It is gathered in sumps and delivered to the surface by pumps.

Haulage

Three storage-battery locomotives are used for gathering. The main parting or storage track is at the bottom of the rock slope, and these locomotives take empties to the face roadways and return with loads to the slope parting. Trips are usually of 6 cars which have a capacity of approximately 1.5 tons each.

Hoisting

At the slope bottom a rope is attached to the six loaded cars, which are hoisted up the slope to the tipple by a 300-horsepower steam hoist.

Tipple and Surface Plant

The tipple is of steel. The cars are spotted on a track adjacent to a steam ram, which pushes the large blocks of coal off the mine car onto a conveyor. The latter delivers the coal to a machine that cuts the bony from the top of the coal; then the coal goes to a pick crusher, which breaks the large chunks, and thence onto shaking screens for preparation into commercial sizes. These sizes vary according to demand and are:

Inches	Grade
10	Lump
6 by 10	Do.
3 by 6	Egg
2 1/2 by 3/4	Nut
3/4	Screenings

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Mine employees, based on production of 240 tons per day

Class	Number of men	Hours worked per day	Total man-hours per day	
Fireboss (gasman)	1	7	7	
Timberman	2	7	14	
Trackmen	2	7	14	
Motormen	3	7	21	
Brushers	3	7	21	
Scowmen	24	7	168	
Chunkers	6	7	42	
Engineer at loading head	3	7	21	
Scow operator	3	7	21	
Face bosses	3	7	21	
3 machine crews (2 shifts)	18	7	126	
Mine foreman	1	8	8	
Total men underground	69		484	484
Top employees				
Engineer	1	8	8	
Foremen	3	8	24	
Miscellaneous topmen	12	7	84	
Total topmen	16		116	116
Total all employees	85			600

Summary

Class	Number of men	Total man-hours per day	Tons per man per day	Man-hours per ton per day
Loading	36	252	6.67	1.050
Entry brushing	3	21	80.00	.087
Coal cutting	18	126	13.33	.525
Haulage and hoisting	5	37	48.00	.154
Miscellaneous underground	9	64	26.67	.267
Miscellaneous topmen	14	100	17.14	.417
Total	85	600	2.82	2.500

This mine is an example of a longwall mine in a thin seam, using scows.

LE FLORE COUNTY, OKLA.

The area visited is adjacent to Poteau, the county seat of Le Flore County. The topography is rough, with steep hills and narrow valleys.

The Cavanal coal seam, mined in the operation described, averaged 26 inches in thickness and was free from partings. On top of the coal and adhering to it was a hard, sandy shale material containing some pyrite (bony). This bony averaged 3 to 4 inches in thickness. Above the bony was a hard, sandy shale, locally called a black slate. The bottom under the coal seam was a hard, sandy fireclay and shale. The coal seam outcropped on the hillside approximately 30 feet above the valley. The coal seam dips toward the axis of the Cavanal syncline which strikes northeast-southwest.[7]

The coal is sold in the markets of the Middle West as a high-grade semi-anthracite. It is used principally for domestic purposes.

Mine No. 11

The mine is in Le Flore County, Okla., near Poteau, the county seat. It has railroad connections, and the production is shipped to markets in the Middle West.

The coal seam has been designated locally as the Poteau but geologically has been correlated as the Cavanal. It outcrops on the hillsides above the valley along the contour of the hills. The average thickness of the seam is 26 inches, and it is clean and free from partings. There is a bony seam 3 to 4 inches thick on top of the coal. This bony adheres to the coal but separates readily from the overlying roof. The roof is a hard, sandy shale (black slate), and the bottom is a hard, sandy fireclay and shale. In some places the bottom contains large quantities of pyrite nodules. When this condition exists, undercutting in the bottom beneath the coal is impractical, and cutting is done in the coal seam. The average dip of the seam is 7 percent.

System of Mining

A slope was driven approximately 3,000 feet down the dip of the seam from the outcrop. The mine was originally developed with entries turned off the slope to the right and to the left for extracting the coal through individual roadways. This system was abandoned, and the mine at present is being developed for the use of scows.

Branch entries were turned to the right and left from the slope at approximately 300-foot intervals. The distance between entries varies due to the irregular contour of the outcrop. The branch entries are driven a few degrees from a right angle off the slope so that the grade favors the loads. At present five branch entries with their corresponding faces are in operation.

Entries or roadways are brushed in the roof approximately 4 feet above the top of the coal to obtain clearance for haulage. The faces are opened on each side of the roadway at right angles to it and approximately parallel to the slope. (See fig. 14.)

Five longwall mining machines operate at the face, one for each roadway. Four of these machines are equipped with 3 1/2-foot, and one with a 3-foot cutter bar. These machines undercut the coal at night. All cutting is done in

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[7] Shannon, C. W., and Others, Coal in Oklahoma: Oklahoma Geol. Survey, Bull. 4, 1926, pp. 82-83.

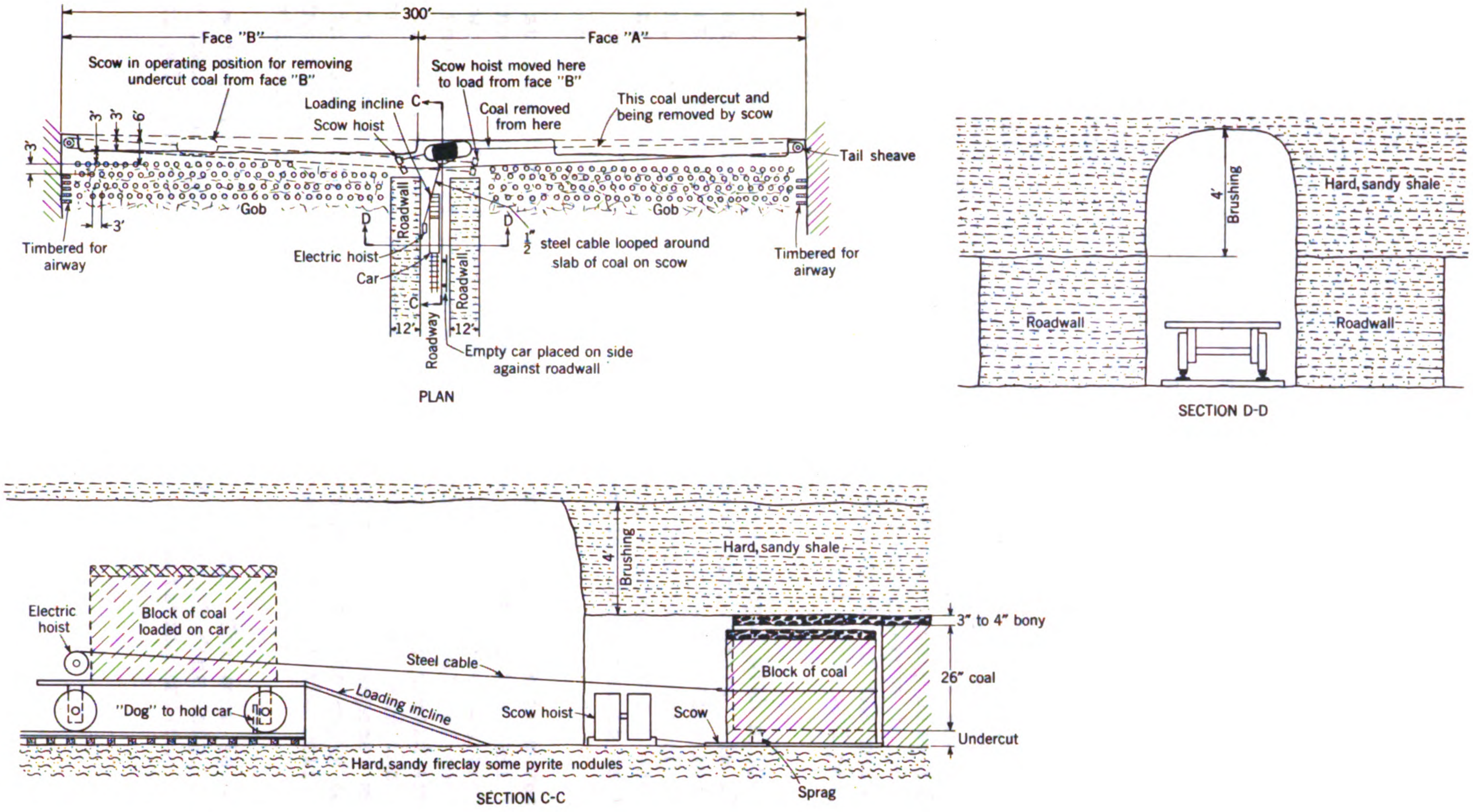

Figure 14.—Plan of longwall face using scow—Le Flore County, Okla.

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the bottom beneath the coal except at one face, where it is necessary to cut in the bottom of the coal seam itself due to the nodules of pyrite in the material under the coal. The machines cut a 5-inch kerf. Each machine crew consists of a runner, helper, and shoveler. Wooden sprags are placed in the cut as the machine progresses along the face. Machine cuttings are thrown into the gob. The rate of cutting is approximately 50 to 60 feet an hour. The length of the faces varies according to the distance between roadways.

Brushing is done at night by two men for each roadway. These men drill the rock above the coal, shoot, and build a packwall, averaging 10 feet in width, on each side of the roadway from the brushing rock. The brushing and walls are advanced with each advance of the face. The roadways are timbered where necessary.

The men who do the brushing set a row of props along the face on approximately 3 1/2-foot centers and 3 feet from the face. These timbers support the roof and permit passage of the mining machine. These men also drill a hole in the coal at the face of the roadway after it had been undercut and shoot down the coal at this point. This is called the "break-in." They also take out enough coal at each end of the face after it has been undercut to permit them to place the tail sheaves for the scow. With the assistance of the machinemen, they move the scow hoist ahead one cut and install the steel cable and prepare the scow for operation by the loading crew.

The hoists for pulling the scows are usually equipped with a 12- to 14-inch double drum and are driven by 20- to 25-horsepower a.c. motors. In all but one face (520 feet) the scows load out one side of the face at a time and pull from one direction. In the exception, the scow loads from both sides of the face without moving the hoist. The arrangement of the equipment for a one-sided scow operation is shown in figure 14, and for a two-sided operation it is the same as shown in figure 13 (mine No. 10).

The hoist pulls the scow into the cut under the coal; as it moves ahead the sprags are knocked out, and the pressure of the roof causes the coal to fall onto the scow. The slab of coal breaks off at the solid face and over a length governed by the position of the sprags. When the scow is full of coal it is pulled back to the roadway. At this point a steel cable is placed around the large slab of coal. The cable forms a loop around the coal, and the other end is attached to a small electric hoist (driven by a 7 1/2-horsepower motor), which drags the slab onto a loading plate and thence onto the empty car. The car has a flat top approximately 13 inches above the top of the rail. The cars are 3 feet wide and 7 feet long.

The scow is made of a steel plate 1/4 inch thick. The scow is usually 6 inches wider than the depth of the undercut and 16 to 20 feet long. The steel cable used to pull the scow is 1/2 inch by 6 by 19 hoisting cable.

Each roadway has a single track, and empty cars are turned over on their side off the track and against the roadwall at the loading chute. As the cars are loaded they are pushed down the track to a stop, and the empty cars are placed back on the track and taken to the loading chute. After 10 cars are loaded, the trip is taken to the parting or storage track at the slope. Ten cars usually comprise a trip.

The following are the faces in operation at this mine, with the length of each and employees.

No. 1 - 520 feet of face.

1 machine crew of 3 men. It requires about 10 hours to cut this length of face.
1 engineer at scow hoist.
2 men at the roadhead. They operate the hoist which pulls the slabs of coal from the scow to the loading chute and load the coal onto cars.
2 men at the face, who attend to the loading of the scow.
1 driver, who delivers empties and loads.
2 brushers, who work at night.
11 men - total.

No. 2 - 400 feet of face.

1 machine crew of 3 men.
1 scow engineer.
2 roadhead men.
1 faceman.
1 driver.
2 brushers.
10 men - total.

Nos. 3 and 4 - each 300 feet of face.

1 machine crew of 3 men for each face.
1 scow engineer for each face.
2 roadhead men for each face.
1 faceman for each face.
1 driver for each face.
2 brushers for each face.
10 men - total.

No. 5 - 275 feet of face.

1 machine crew of 3 men.
1 scow engineer.
2 roadhead men.
1 faceman.
1 driver.
2 brushers.
10 men - total.

Roof Support and Control

At present the maximum depth to the coal seam is approximately 200 feet. The weight of the overburden is supported at the roadways by the solid rock or pack walls 10 feet wide. The support between roadways is entirely by timber props, which average 5 inches in diameter. No timber cribs are necessary.

As the face is advanced, a row of props is set 3 feet back of the solid face of coal. The props are staggered in each row on approximately 3 1/2-foot centers. The unsupported roof from prop line to solid face is about 6 to 7 feet. The roof settles gradually. The action of the roof is first noted on the second or third row of props from the face and is shown by the gradual spreading or "mushrooming" of the head of the props. Pine timbers are used, as they mushroom instead of breaking suddenly. Should it be noted that the weight is advancing closer to the face than the second row of props, a double row of timbers is immediately set next to the face.

Breaks in the roof occur at irregular intervals. Particular attention is paid to the progress of the weight toward the face. Should a sudden break occur and the undercut coal is mashed down, it is necessary to shoot the coal as off the solid and start a new face. If any rapid settling of the roof is noted, timbers are immediately set at some distance from the maximum movement, and the timbering is carried toward the point where the greatest movement is occurring. The weight of the overburden is partly on the undercut coal and causes it to break off at the end of the cut, but the greater part of the weight is thrown to the gob.

Haulage and Hoisting

Trips of 10 cars each are usually handled. Empties are lowered down the slope by a 50-horsepower, a.c., electric hoist, which is located on the tipple. The trips are switched into the roadways off the slope requiring cars. In each roadway inside the slope is a parting or storage track. The empties are taken by the driver in 10-car trips to the face of the roadway, and loads are brought back to the parting and pulled back up the slope to the tipple by the electric hoist. The cars have a capacity of approximately 1 1/2 tons each. Track gage is 30 inches.

Ventilation

There are two air shafts, one for each side of the mine.

The air passes down the slope and splits at the face. A current passes to each side of the mine, passes around the faces, and returns to the respective air shafts, which are equipped with fans.

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Tipple and Surface Plant

The tipple is of wooden construction and has two tracks on its deck for loads and one for empties.

The loads are spotted over the rock chute, usually a car on each loaded track. Two men using an air drill equipped with a chisel bit remove the bony from the top of the slabs of coal. The rock is thrown into the rock chute and dumped into a car, which is hoisted over an incline dump to the rock disposal. A chain on which lugs are fastened runs under the car containing the clean coal and pulls it to the dumping cradle.

The coal is dumped into a chute and passes to a pick breaker, which splits the large slabs of coal into large chunks. From the breaker it passes into a chute, where a man using an air drill equipped with a chisel bit breaks the large chunks into smaller lumps. From there it passes to the shaking screens for sizing. The following sizes are made according to the demand:

Inches	Grade	Percent
-2 1/2	Nut run	10
2 1/2 by 6	Grate	15
6 by 10	Junior lump	25
10 by 14	Fancy lump	50

Mine employees, based on production of 200 tons per day

Class	Number of men	Hours worked per day	Total man-hours per day	
Air and timber man..............	1	7	7	
Fireboss (gasman)...............	1	7	7	
Rope rider......................	1	7	7	
5 machine crews.................	15	8.2	123	
Engineers.......................	5	7.2	36	
Drivers.........................	5	7.2	36	
Roadhead men....................	10	7.2	72	
Facemen.........................	6	7.33	44	
Brushers........................	10	7	70	
Mine foreman....................	1	8	8	
Total men underground.........	55		410	410
Topmen				
Engineer........................	1	8	8	
Topmen..........................	6	7	42	
Blacksmith......................	1	7	7	
Total topmen..................	8		57	57
Total all employees...........	63			467

Summary

Class	Number of men	Total man-hours per day	Tons per man per day	Man-hours per ton per day
Loading....................	21	152	9.52	0.760
Brushing..................	6-2/3[1]	46-2/3	30.00	.233
Coal cutting..............	15	123	13.33	.615
Haulage and hoisting.......	7	51	28.57	.255
Miscellaneous underground..	6-1/3[1]	45-1/3	31.63	.227
Miscellaneous topmen.......	7	49	28.57	.245
Total.................	63	467	3.17	2.335

[1] One-third of number of brushers charged to miscellaneous underground, and two-thirds to brushing.

This mine is an example of a longwall mine, using scows and brushing the roof of entries or roadways instead of the bottom.

SOUTHERN IOWA - APPANOOSE COUNTY

General Description of the District

The topography of this area is hilly, and it is drained by many small streams, the principal one being the Chariton River. The average elevation is approximately 1,000 feet above sea level.

The county seat is Centerville, a town of 8,000 inhabitants.

The Chicago, Rock Island & Pacific, Chicago, Burlington & Quincy, and Minneapolis & St. Louis Railroads and the Iowa Southern Utilities electric railroad serve mines in this county.

General Geology

The formation which predominates over this area is the Des Moines stage of the Pennsylvanian system. The Des Moines stage is generally divided into three general divisions, the Pleasanton, the Appanoose, and the Cherokee. The Appanoose contains the Mystic coal seam, which is the most important one in the area visited. The depth to this seam varies due to the surface topography.

The Mystic seam is very persistent over a large area and varies little in thickness, the average being 30 inches, including the parting. The chief characteristic of the seam is the clay band 1/2 inch to 2 inches thick which occurs in the middle. Immediately above the coal is a stratum of black to blue shale, called locally a "slate." Occasionally it is soft and claylike; then it is called "clod." At times it is hard and heavy and then is called "black bat." This slate invariably falls after the coal has been removed. It makes an ideal roof until a break occurs. Contact with the air causes it to disintegrate and fall.

Above this slate is a hard subcrystalline limestone 2 to 4 feet thick, known as the "cap rock." Immediately under the coal is a seam of clay 1/2 to 1 inch thick, then a seam of bony coal called the "dutchman." The latter varies in thickness but in the mine visited averaged 1 1/2 inches. Under the dutchman is a fireclay stratum averaging 24 inches in thickness, and below it a limestone called the "bottom rock." See figure 15 for a sketch section of the coal seam and under and overlying strata.

The coal seam lies comparatively level, although there may be local dips. Occasionally a slip or fault is encountered, and adjacent to it an area of low coal.

A proximate analysis of this coal as received, given by the operator of the mine visited, is as follows:

Moisture lost at 105°...	percent	11.65
Ash.....................	Do.	12.32
Volatile matter.........	Do.	29.38
Sulphur.................	Do.	3.41
Fixed carbon............	Do.	43.24
B.t.u.		11,980

Mine No. 12

This mine is in the Centerville district and has railroad connections. The daily production averages 500 tons in a 7-hour shift. Practically all of the output is sold commercially, but some railroad fuel is loaded.

The main shaft, which is 110 feet deep, has two hoisting compartments and is the upcast in the ventilating system. The air shaft, which contains a compartment for the escapeway, is the downcast. Air is furnished by a 4-foot high-speed fan.

Power for the operation of hoist, fan, mining machines, and other equipment at the mine is purchased from a public utility company and is 60-cycle, 3-phase a.c.

System of Mining

The system of advancing longwall with individual roadways is used. Following the general practice in this method of mining the hoisting shaft is in the center of the acreage to be developed. A pillar of solid coal is left around the shaft to protect it and the bottom of the mine. The width of the pillar usually equals the depth of the shaft. The air shaft is not less than 300 feet from the hoisting shaft. As a general rule no pillar is left to protect it, since the alinement of this shaft is not so important.

From the shaft a main entry runs toward the property lines. Cross entries are driven both to the right and to the left, from the main entry, usually at an angle of 45° therefrom. The distance between center lines of the cross entries ranges from 100 to 125 feet. These cross entries are called "skips" in this field. The individual roadways are turned off the skips at 45° toward the face and on varying center lines, 30 to 50 feet. Figure 15 is a map showing the method of development used in this mine.

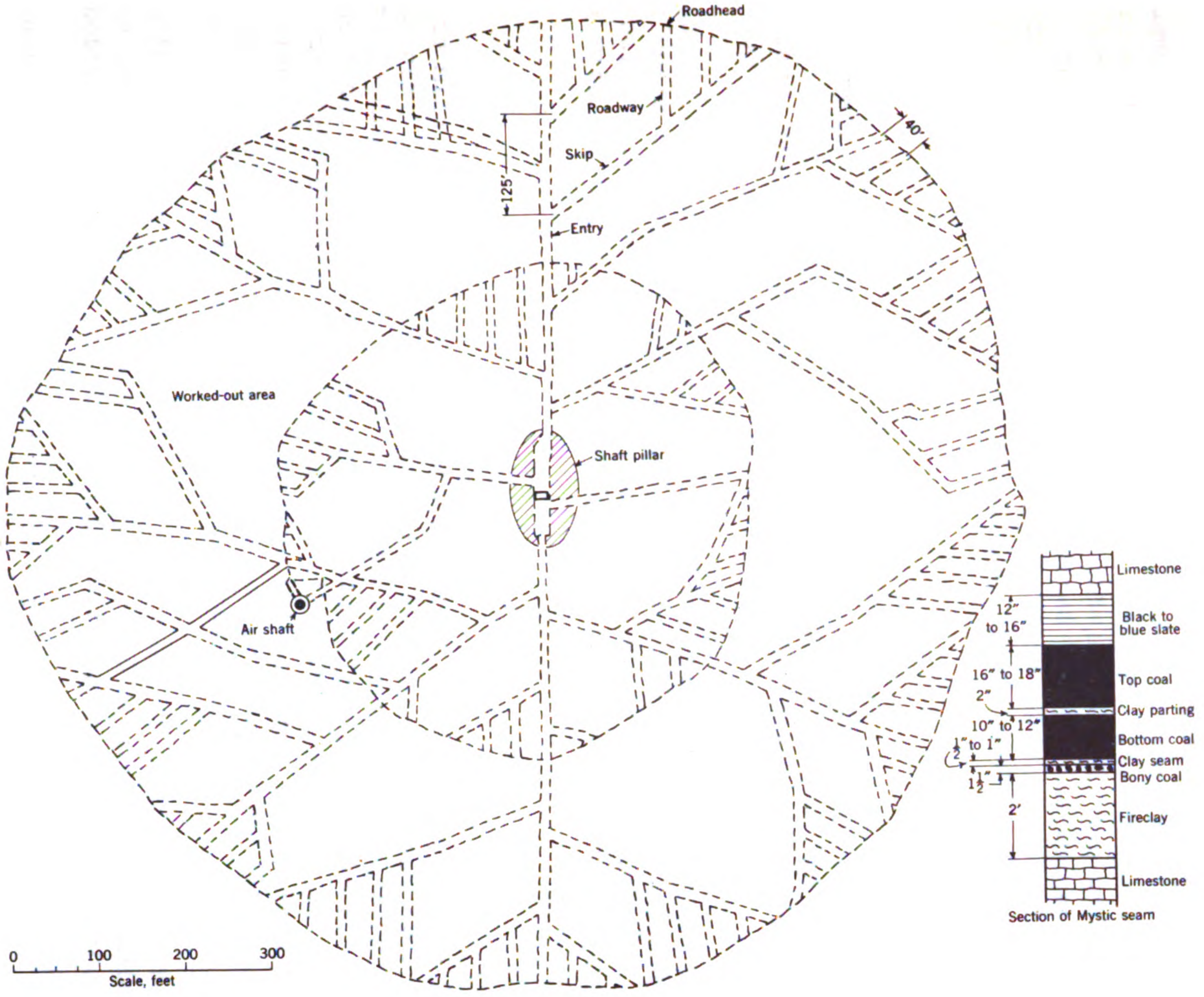

Figure 15.–Map of longwall mine, Centerville (Iowa) district.

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Entries, skips, and roadways are brushed in the fireclay bottom beneath the coal to a depth of 22 to 24 inches. The fireclay is dug out in large chunks with picks and is used to build the roadwalls and pillars (packs), which are placed along the face. The bottom in the entries and roadways is brushed 5 feet wide, and the walls are built on each side. The width between walls is usually 8 feet. The blue or black slate above the coal often falls on exposure to the air, and the height of the roadways after brushing ranges from 5 feet 6 inches to 6 feet. As the roof settles, due to the weight of the overburden, the height of the roadways is reduced to 44 or 48 inches, the average height of haulageways in the mine. The limestone cap rock is seldom brushed. The miner is paid a stated amount per linear yard for brushing entries in the bottom.

Cutting

Four longwall mining machines equipped with 30-inch cutter bars are used in this mine. They usually work two shifts per day and follow one another around the face, which is in the form of an arc. One machine cuts an average of 400 to 500 feet per shift.

Cutting is done in the fireclay beneath the dutchman. Sprags are placed in the cut under the coal to prevent its falling until the miner is ready to load the coal. Three men operate the machine, a runner and two helpers. They are paid a rate per ton on all coal cut by their machine and loaded from the face.

Loading

In this mine one man loads from each roadhead. If he is unable to load out all the coal down in his place in a shift, assistance is given him. In addition to loading his coal he must keep his place securely propped within 3 feet of the face. The props are set on approximately 3-foot centers. He also builds pillars (packs) from the dutchman and other foreign matter in the coal along the line of these timbers. The machine cuttings are thrown into the gob back of this line of timbers and packs. The loader brushes the entries, skips, and roadways and from the brushing builds the roadwalls.

Where the roadways are turned off the skip a cog or crib is built to support the roof. This is constructed of props laid crisscross, extending from the bottom to the roof, and the opening is filled with brushing rock.

Cars are delivered to the loader at the switch off the skip to his roadhead.

Roof Support and Control

The roof is supported by the roadwalls along the entries, skips, and roadways and by the packs along the face. The slate roof is held up temporarily by props. Breaks in the limestone caprock usually occur after each cut of coal is removed. These breaks show as corrugations approximately 30 inches apart in the cap rock. The weight of the overburden acting on the roof breaks down the coal that has been undercut. The roof slopes from the face back to a point approximately 100 feet from it. At this point the full amount of subsidence appears to be reached. The breaks in the cap rock do not always reach the surface, due, no doubt, to the fact that the limestone grades into a shale that seals the break. Although there is water in some of the overlying strata, it does not enter the mine through these breaks, due possibly to the sealing of the openings by the shale.

About one prop is used per ton of coal mined.

Haulage

Because of the low height of the entries, Shetland ponies are used for gathering. These animals are stocky and weigh about 550 pounds. They work in teams of two ponies each and pull 4 to 6 cars having a capacity of 1,500 pounds of coal each. The track gage is 36 inches.

The coal is gathered from the roadway switches to the partings and from there it is hauled in trips of 10 to 15 cars to the shaft bottom by electric trolley locomotives. One 6-ton and one 3-ton locomotive are in use in this mine.

Shaft Bottom

The bottom is double-tracked for both loads and empties. Caging is done from one side. The empty is pushed off the cage by the load and runs downgrade to the empty storage tracks. Loads are brought aroung the shaft from the empty side of the mine for caging over a runaround track.

Hoisting

Cars are hoisted on self-dumping cages. The coal is emptied from the cars into a weigh hopper in the tipple, and after being weighed goes to the crusher and shaking screens. The hoist is 110-horsepower, and is operated by remote control. The engineer is stationed in the tipple.

Rock that is not needed for the building of roadwalls and packs and cannot be gobbed in the mine is hoisted and dumped into the rock chute. From there it is dumped into the rock car and hoisted over an incline to the top of the rock dump for disposal.

Tipple and Surface Plant

After being weighed in the weigh hopper, the coal is dumped into a cylindrical breaker, which contains picks that break the large slabs of coal into commercial sizes. After breaking, the coal goes over shaking screens for sizing. The following sizes are made:

Inches	Grade	Percent
+12	Lump	60
6 by 12	Junior lump	
2 by 6	Egg	30
4 by 8	do.	
2 by 4	do.	
2 by 1 1/4	Nut	
1 1/4	Screenings	10

Prepared coal is loaded in both box and open cars. Box-car loaders are used to load the coal into this type of car. Severe weather causes the larger lumps of coal to disintegrate, and these sizes are shipped in box cars.

Mine employees, based on production of 500 tons per day

Class	Number of men	Hours worked per day	Total man-hours	
Cagers	1	8	8	
Cager's helpers	3	7	21	
Drivers	9	7	63	
Motormen	2	7	14	
Trackmen	4	7	28	
Face boss	1	7	7	
Mine foreman	1	7	7	
Total day-wage employees underground	21		148	148
4 machine crews (day) by ton	12	7	84	
4 machine crews (night) by ton	12	7	84	
Loaders (by ton)	145	7	1,015	
			1,183	1,183
Total men underground	190			1,331
Top employees				
Engineer	1	8	8	
Weighman	1	7	7	
Box-car loaders and chunkers	5	7	35	
Topmen	3	7	21	
Blacksmith	1	7	7	
Total topmen	11		78	78
Total all employees	201			1,409

Summary

Class	Number of men	Total man-hours per day	Tons per man per day	Man-hours per ton per day
Loading	145	1,015	3.44	2.030
Coal cutting	24	168	20.83	.336
Haulage and hoisting	16	114	31.25	.228
Miscellaneous underground	6	42	83.33	.084
Miscellaneous top	10	70	50.00	.140
Total	201	1,409	2.49	2.818

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Deadwork cost and deficiencies are estimated at 10 percent of total labor cost per working day.

This mine is an example of advancing longwall mining, with individual roadways, in a 28-inch seam of coal.

CONCLUSIONS

1. Each mine described appears to be a problem in itself.

2. There seems to be no proportionate relation between thickness of the coal seam and the ton output per man employed.

3. The output per man seems to be greatest at mines using some mechanical loading device.

4. Advancing longwall mining is possible in seams as thick as 4 feet 6 inches provided the roof can be supported on rock pillars or packs.

5. In seams over 30 inches, it appears that timber alone for the support of the overburden is not practical, especially if the depth to the coal seam is considerable.

6. For successful scow operations, the seam of coal must separate easily from the roof; the seam must be compact and after undercutting, fall without disintegration.

7. The success of any longwall system of mining depends upon control of the weight of the overburden. The support for the overlying strata must be pliable and yield gradually to subsidence of the overburden.

Recapitulation
(Arranged according to thickness of seam)

Mine No.	Thickness of seam, inches	Loading			Brushing			Cutting			Haulage and hoisting		
		No. men	Tons per man	Man-hours per ton	No. men	Tons per man	Man-hour per ton	No. men	Tons per man	Man-hours per ton	No. men	Tons per man	Man-hour per ton
6	18	145	3.65	1.915	10	53.00	0.136	32.5	16.30	0.429	20	26.50	0.269
10	18	36	6.67	1.050	3	80.00	.087	18	13.33	.525	5	48.00	.154
9	21	57	6.31	1.108	3	120.00	.058	11	32.72	.214	8	45.00	.158
5	22	100	2.50	3.200	-	-	-	33	7.57	1.056	10	25.00	.332
11	26	21	9.52	.760	6.67	30.00	.233	15	13.33	.615	7	28.57	.255
12	28	145	3.44	2.030	-	-	-	24	20.83	.336	16	31.25	.228
7	30	75	6.00	1.333	10	45.00	.178	20	22.50	.355	13	34.61	.238
8	30	33	9.85	.720	6	54.16	.129	9	36.11	.221	7	46.42	.157
1	42	194	3.61	1.940	19	36.84	.190	10	70.00	.100	27	25.92	.274
2	42	114	2.63	2.660	2	150.00	.047	Hand cutting			17	17.65	.403
4	54	202	4.95	1.414	23	43.48	.161	21	47.62	.150	33	30.33	.246

Recapitulation - Continued
(Arranged according to thickness of seam)

Mine No.	Misc. underground			Miscellaneous top			Total			Tons per day
	No. men	Tons per man	Man-hour per ton	No. men	Tons per man	Man-hour per ton	No. men	Tons per man	Man-hours per ton	
6	5	106.00	0.068	4.50	117.77	0.059	217	2.44	2.876	1/530
10	9	26.67	.267	14	17.14	.417	85	2.82	2.500	2/240
9	7	51.43	.139	15	24.00	.292	101	3.56	1.969	3/360
5	4	62.50	.128	11	22.72	.356	158	1.58	5.072	1/,4/250
11	6.33	31.63	.227	7	28.57	.245	63	3.17	2.335	2/200
12	6	83.33	.084	10	50.00	.140	201	2.49	2.818	1/500
7	5	90.00	.089	8	56.25	.142	131	3.43	2.335	3/450
8	13	25.00	.292	5	65.00	.108	73	4.45	1.627	3/325
1	6	116.67	.060	13	53.84	.130	269	2.60	2.694	1/700
2	6	50.00	.140	7	42.85	.167	146	2.06	3.417	4/300
4	12	83.33	.084	10	100.00	.076	301	3.32	2.131	1/,3/1,000

1/ Hand loading following mining machines.
2/ Scow loading following mining machines.
3/ Conveyor loading following mining machines.
4/ Hand loading and hand mining.

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